REPORT

OF THE

THIRTEENTH MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE;

HELD AT CORK IN AUGUST 1843.

LONDON:

JOHN MURRAY, ALBEMARLE STREET.

1844.

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OF

THE ASSOCIATION.

OBJECTS.

The Association contemplates no interference with the ground occupied by other Institutions. Its objects are,—To give a stronger impulse and a more systematic direction to scientific inquiry,—to promote the intercourse of those who cultivate Science in different parts of the British Empire, with one another, and with foreign philosophers,—to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.

RULES.

MEMBERS.

All Persons who have attended the first Meeting shall be entitled to become Members of the Association, upon subscribing an obligation to conform to its Rules.

The Fellows and Members of Chartered Literary and Philosophical Societies publishing Transactions, in the British Empire, shall be entitled, in like manner, to become Members of the Association.

The Officers and Members of the Councils, or Managing Committees, of Philosophical Institutions, shall be entitled, in like manner, to become Members of the Association.

All Members of a Philosophical Institution, recommended by its Council or Managing Committee, shall be entitled, in like manner, to become Members of the Association.

Persons not belonging to such Institutions shall be elected by the General Committee or Council, to become Members of the Association, subject to the approval of a General Meeting.

SUBSCRIPTIONS.

The amount of the Annual Subscription shall be One Pound, to be paid in advance upon admission; and the amount of the composition in lieu thereof, Five Pounds.

An admission fee of One Pound is required from all Members elected as Annual Subscribers, after the Meeting of 1839, in addition to their annual subscription of One Pound.

The volume of Reports of the Association will be distributed gratuitously to every Annual Subscriber who has actually paid the Annual Subscription for the year to which the volume relates, and to all those Life Members who shall have paid Two Pounds as a *Book Subscription*.

Subscriptions shall be received by the Treasurer or Secretaries.

If the Annual Subscription of any Member shall have been in arrear for two years, and shall not be paid on proper notice, he shall cease to be a Member.

MEETINGS.

The Association shall meet annually, for one week, or longer. The place of each Meeting shall be appointed by the General Committee at the previous Meeting; and the Arrangements for it shall be entrusted to the Officers of the Association.

GENERAL COMMITTEE.

The General Committee shall sit during the week of the Meeting, or longer, to transact the business of the Association. It shall consist of the following persons :—

1. Presidents and Officers for the present and preceding years, with authors of Reports in the Transactions of the Association.

2. Members who have communicated any Paper to a Philosophical Society, which has been printed in its Transactions, and which relates to such subjects as are taken into consideration at the Sectional Meetings of the Association.

3. Office-bearers for the time being, or Delegates, altogether not exceeding three in number, from any Philosophical Society publishing Transactions.

4. Office-bearers for the time being, or Delegates, not exceeding three, from Philosophical Institutions established in the place of Meeting, or in any place where the Association has formerly met.

5. Foreigners and other individuals whose assistance is desired, and who are specially nominated in writing for the Meeting of the year by the President and General Secretaries.

6. The Presidents, Vice-Presidents, and Secretaries of the Sections are *ex officio* members of the General Committee for the time being.

SECTIONAL COMMITTEES.

The General Committee shall appoint, at each Meeting, Committees, consisting severally of the Members most conversant with the several branches of Science, to advise together for the advancement thereof.

The Committee shall report what subjects of investigation they would particularly recommend to be prosecuted during the ensuing year, and brought under consideration at the next Meeting.

The Committees shall recommend Reports on the state and progress of particular Sciences, to be drawn up from time to time by competent persons, for the information of the Annual Meetings.

COMMITTEE OF RECOMMENDATIONS.

The General Committee shall appoint at each Meeting a Committee, which shall receive and consider the recommendations of the Sectional Committees, and report to the General Committee the measures which they would advise to be adopted for the advancement of Science.

All Recommendations of Grants of Money, Requests for Special Researches, and Reports on Scientific Subjects, shall be submitted to the Committee of Recommendations, and not taken into consideration by the General Committee unless previously recommended by the Committee of Recommendations.

LOCAL COMMITTEES.

Local Committees shall be formed by the Officers of the Association to assist in making arrangements for the Meetings.

Local Committees shall have the power of adding to their numbers those Members of the Association whose assistance they may desire.

OFFICERS.

A President, two or more Vice-Presidents, one or more Secretaries, and a Treasurer, shall be annually appointed by the General Committee.

COUNCIL.

In the intervals of the Meetings, the affairs of the Association shall be managed by a Council appointed by the General Committee. The Council may also assemble for the despatch of business during the week of the Meeting.

PAPERS AND COMMUNICATIONS.

The Author of any paper or communication shall be at liberty to reserve his right of property therein.

ACCOUNTS.

The Accounts of the Association shall be audited annually, by Auditors appointed by the Meeting.

OFFICERS AND COUNCIL, 1843—44.

Trustees (permanent).—Francis Baily, Esq., F.R.S. Roderick Impey Murchison, Esq., F.R.S., Pres. G.S. John Taylor, Esq., F.R.S., Treas. G.S.

President.—The Earl of Rosse.

Vice-Presidents.—The Earl of Listowel. Visc. Adare, M.P., F.R.S. Sir W. R. Hamilton, R.I.A. Rev. T. R. Robinson, D.D.

President Elect.—The Very Reverend George Peacock, D.D., Dean of Ely.

Vice-Presidents Elect.—The Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S. The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H. Michael Faraday, Esq., F.R.S. Rev. William V. Harcourt, F.R.S.

General Secretaries.—Roderick Impey Murchison, Esq., F.R.S., Pres. G.S., London. Lieut.-Col. Sabine, F.R.S., Woolwich.

Assistant General Secretary.—Professor Phillips, F.R.S., York.

General Treasurer.—John Taylor, Esq., F.R.S., 2 Duke Street, Adelphi, London.

Secretaries for the York Meeting in 1844.—William Hatfeild, Esq., F.G.S. Thomas Meynell, Esq., F.L.S. Rev. W. Scoresby, LL.D., F.R.S. William West, Esq.

Treasurer to the Meeting in 1844.—William Gray, jun., Esq., F.G.S.

Council.—Sir H. T. De la Beche. Rev. Dr. Buckland. Dr. Daubeny. Professor T. Graham. J. E. Gray, Esq. G. B. Greenough, Esq. James Heywood, Esq. Eaton Hodgkinson, Esq. Leonard Horner, Esq. Robert Hutton, Esq. Sir Charles Lemon, Bart. Rev. Professor Lloyd. Charles Lyell, Esq. Professor MacNeill. Professor MacCullagh. Professor Moseley. The Marquis of Northampton. Dr. Richardson. Rev. Professor Sedgwick. Lieut.-Col. Sykes. William Thompson, Esq. Professor Wheatstone. Rev. William Whewell (Master of Trin. Coll., Cambridge). C. J. B. Williams, M.D.

Local Treasurers.—Dr. Daubeny, Oxford. C. C. Babington, Esq., Cambridge. Dr. Orpen, Dublin. W. Ramsay, Esq., Edinburgh and Glasgow. William Gray, jun., Esq., York. William Sanders, Esq., Bristol. Samuel Turner, Esq., Liverpool. G. W. Ormerod, Esq., Manchester. James Russell, Esq., Birmingham. William Hutton, Esq., Newcastle-on-Tyne. Henry Woollcombe, Esq., Plymouth. James Roche, Esq., Cork.

Auditors.—William Yarrell, Esq. James Heywood, Esq. Professor MacNeill.

I. Table showing the Places and Times of Meeting of the British Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Commencement.

Presidents.	Vice-Presidents.	Local Secretaries.
The EARL FITZWILLIAM, D.C.L., F.R.S., F.G.S., &c. YORK, September 27, 1831.	Rev. W. Vernon Harcourt, M.A., F.R.S., F.G.S.	William Gray, jun., F.G.S. Professor Phillips, F.R.S., F.G.S.
The REV. W. BUCKLAND, D.D., F.R.S., F.G.S., &c. OXFORD, June 19, 1832.	Sir David Brewster, F.R.SS.L. & E., &c. Rev. W. Whewell, F.R.S., Pres. Geol. Soc.	Professor Daubeny, M.D., F.R.S., &c. Rev. Professor Powell, M.A., F.R.S., &c.
The REV. ADAM SEDGWICK, M.A., V.P.R.S., V.P.G.S. CAMBRIDGE, June 25, 1833.	G. B. Airy, F.R.S., Astronomer Royal, &c. John Dalton, D.C.L., F.R.S.	Rev. Professor Henslow, M.A., F.L.S., F.G.S. Rev. W. Whewell, F.R.S.
Sir T. MACDOUGAL BRISBANE, K.C.B., D.C.L., F.R.SS. L. & E. EDINBURGH, September 8, 1834.	Sir David Brewster, F.R.S., &c. Rev. T. R. Robinson, D.D.	Professor Forbes, F.R.S., L. & E., &c. Sir John Robison, Sec. R.S.E.
The REV. PROVOST LLOYD, LL.D. DUBLIN, August 10, 1835.	Viscount Oxmantown, F.R.S., F.R.A.S. Rev. W. Whewell, F.R.S., &c.	Sir W. R. Hamilton, Astron. Royal of Ireland, &c. Rev. Professor Lloyd, F.R.S.
The MARQUIS OF LANSDOWNE, D.C.L., F.R.S., &c. BRISTOL, August 22, 1836.	The Marquis of Northampton, F.R.S. Rev. W. D. Conybeare, F.R.S., F.G.S. J. C. Prichard, M.D., F.R.S.	Professor Daubeny, M.D., F.R.S., &c. V. F. Hovenden.
The EARL OF BURLINGTON, F.R.S., F.G.S., Chan. Univ. London. LIVERPOOL, September 11, 1837.	The Bishop of Norwich, P.L.S., F.G.S. John Dalton, D.C.L., F.R.S. Sir Philip Grey Egerton, Bart., F.R.S., F.G.S. Rev. W. Whewell, F.R.S.	Professor Traill, M.D. Wm. Wallace Currie, Esq. Joseph N. Walker, Pres. Royal Institution, Liverpool.
The DUKE OF NORTHUMBERLAND, F.R.S., F.G.S., &c. NEWCASTLE-ON-TYNE, August 20, 1838.	The Bishop of Durham, F.R.S., F.S.A. The Rev. W. Vernon Harcourt, F.R.S., &c. Prideaux John Selby, Esq., F.R.S.E.	John Adamson, F.L.S., &c. Wm. Hutton, F.G.S. Professor Johnston, M.A., F.R.S.
The REV. W. VERNON HARCOURT, M.A., F.R.S., &c. BIRMINGHAM, August 26, 1839.	The Marquis of Northampton The Earl of Dartmouth The Rev. T. R. Robinson, D.D. John Corrie, Esq., F.R.S. Very Rev. Principal Macfarlane	George Barker, Esq., F.R.S. Peyton Blakiston, M.D. Joseph Hodgson, Esq., F.R.S. Follett Osler, Esq.
The MOST NOBLE THE MARQUIS OF BREADALBANE. GLASGOW, September 17, 1840.	Major-General Lord Greenock, F.R.S.E. Sir David Brewster, F.R.S. Sir T. M. Brisbane, Bart., F.R.S.	Andrew Liddell, Esq. Rev. J. P. Nicol, LL.D. John Strang, Esq.
The REV. PROFESSOR WHEWELL, F.R.S., &c. PLYMOUTH, July 29, 1841.	The Earl of Mount Edgecumbe The Earl of Morley Lord Eliot, M.P. Sir C. Lemon, Bart. Sir T. D. Acland, Bart.	Wm. Snow Harris, Esq., F.R.S. Col. Hamilton Smith, F.L.S. Robert Were Fox, F.R.S. Richard Taylor, jun., Esq.
LORD FRANCIS EGERTON, F.G.S. MANCHESTER, June 23, 1842.	John Dalton, D.C.L., F.R.S. Hon. and Rev. W. Herbert, F.L.S., &c. Rev. A. Sedgwick, M.A., F.R.S. W. C. Henry, M.D., F.R.S. Sir Benjamin Heywood, Bart.	Peter Clare, Esq., F.R.A.S. W. Fleming, M.D. James Heywood, Esq., F.R.S.
The EARL OF ROSSE. CORK, August 17, 1843.	Earl of Listowel Viscount Adare Sir W. R. Hamilton, Pres. R.I.A. Rev. T. R. Robinson, D.D.	Professor John Stevelly, M.A. Rev. Jos. Carson, F.T.C. Dublin. Wm. Keleher, Esq. Wm. Clear, Esq.
The REV. G. PEACOCK, D.D., (Dean of Ely), F.R.S. YORK, September, 1844.	The Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S. The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H. Michael Faraday, Esq., F.R.S. Rev. W. V. Harcourt, F.R.S.	William Hatfeild, Esq., F.G.S. Thomas Meynell, Esq., F.L.S. Rev. W. Scoresby, LL.D., F.R.S. William West, Esq.

II. Table showing the Members of Council of the British Association from its commencement, in addition to Presidents, Vice-Presidents, and Local Secretaries.

General Secretaries.	Rev. Wm. Vernon Harcourt, F.R.S., &c.	1832—1836.
	Francis Baily, V.P. and Treas. R.S.	1835.
	R. I. Murchison, F.R.S., F.G.S.	1836—1843.
	Rev. G. Peacock, F.R.S., F.G.S., &c.	1837, 1838.
	Lieut.-Colonel Sabine, V.P.R.S.	1839, 1843.
General Treasurer.	John Taylor, F.R.S., Treas. G.S., &c.	1832—1843.
Trustees (permanent.)	Charles Babbage, F.R.SS.L. & E., &c. (Resigned.)	
	R. I. Murchison, F.R.S., &c.	
	John Taylor, F.R.S., &c.	
	Francis Baily, F.R.S.	
Assistant General Secretary.	Professor Phillips, F.R.S., &c.	1832—1843.

Members of Council.

G. B. Airy, F.R.S., Astronomer Royal	1834, 1835, 1841.
Neill Arnott, M.D.	1838, 1839, 1840.
Francis Baily, V.P. and Treas. R.S.	1837—1839.
Sir H. T. De la Beche, F.R.S.	1841—1843.
George Bentham, F.L.S.	1834, 1835.
Robert Brown, D.C.L., F.R.S.	1832, 1834, 1835, 1838—1841.
Sir David Brewster, F.R.S., &c.	1832, 1841—1842.
Sir Thomas Brisbane	1842.
Sir M. I. Brunel, F.R.S., &c.	1832.
Rev. Professor Buckland, D.D., F.R.S., &c.	1833, 1835, 1838—1843.
The Earl of Burlington	1838, 1839.
Rev. T. Chalmers, D.D., Prof. of Divinity, Edinburgh	1833.
Professor Clark, Cambridge	1838.
Professor Christie, F.R.S., &c.	1833—1837.
William Clift, F.R.S., F.G.S.	1832—1835.
J. C. Colquhoun, Esq.	1840.
John Corrie, F.R.S., &c.	1832.
Professor Daniell, F.R.S.	1836, 1839.
Dr. Daubeny	1838—1843.
J. E. Drinkwater	1834, 1835.
Sir P. G. Egerton, Bart.	1840, 1841.
The Earl Fitzwilliam, D.C.L., F.R.S., &c.	1833.
Professor Forbes, F.R.SS. L. E., &c.	1832, 1841, 1842.
Davies Gilbert, D.C.L., V.P.R.S., &c.	1832.
Professor R. Graham, M.D., F.R.S.E.	1837.
Professor Thomas Graham, F.R.S.	1838, 1839—1843.
John Edward Gray, F.R.S., F.L.S., &c.	1837—1839, 1840, 1843.
Professor Green, F.R.S., F.G.S.	1832.
G. B. Greenough, F.R.S., F.G.S.	1832—1839—1843.
Henry Hallam, F.R.S., F.S.A., &c.	1836.
Rev. W. V. Harcourt, F.R.S.	1842.
Sir William R. Hamilton, Astron. Royal of Ireland	1832, 1833, 1836.
W. J. Hamilton, Sec. G.S.	1840—1842.
James Heywood, Esq., F.R.S.	1843.
Rev. Prof. Henslow, M.A., F.L.S., F.G.S.	1837.
Sir John F. W. Herschel, F.R.SS. L. & E. F.R.A.S., F.G.S., &c.	1832.
Thomas Hodgkin, M.D.	1833—1837, 1839, 1840.
Eaton Hodgkinson, Esq. F.R.S.	1843.
Prof. Sir W. J. Hooker, LL.D., F.R.S., &c.	1832.
Leonard Horner, F.R.S.	1841—1843.
Rev. F. W. Hope, M.A., F.L.S.	1837.

Robert Hutton, F.G.S., &c.......................1836, 1838, 1839—1843.
Professor R. Jameson, F.R.SS. L. & E.......1833.
Rev. Leonard Jenyns...................................1838.
H. B. Jerrard, Esq. ....1840.
Dr. R. Lee ....1839.
Sir Charles Lemon, Bart..............................1838, 1839, 1842—1843.
Rev. Dr. Lardner ....1838, 1839.
Professor Lindley, F.R.S., F.L.S., &c. ......1833, 1836.
Rev. Professor Lloyd, D.D. ....1832, 1833, 1841—1843.
J. W. Lubbock, F.R.S., F.L.S., &c., Vice-Chancellor of the University of London....1833—1836, 1838, 1839.
Rev. Thomas Luby ....1832.
Charles Lyell, jun., F.R.S. ....1838, 1839, 1840, 1843.
Professor MacCullagh, M.R.I.A...................1843.
William Sharp MacLeay, F.L.S.....................1837.
Professor John Macneill ....1843.
Professor Miller, F.G.S................................1840.
Professor Moseley ....1839, 1840, 1843.
Patrick Neill, LL.D., F.R.S.E......................1833.
The Marquis of Northampton, P.R.S.........1840—1843.
Richard Owen, F.R.S., F.L.S.......................1836, 1838, 1839.
Rev. George Peacock, M.A., F.R.S., &c......1832, 1834, 1835, 1839—1842.
E. Pendarves, Esq..1840.
Rev. Professor Powell, M.A., F.R.S., &c. ...1836, 1837, 1839, 1840.
J. C. Prichard, M.D., F.R.S. &c. ....1832.
George Rennie, F.R.S. ....1833—1835, 1839, 1841.
Sir John Rennie..1838.
Dr. Richardson, F.R.S..................................1841—1843.
Rev. Professor Ritchie, F.R.S......................1833.
Rev. T. R. Robinson, D.D. ....1841.
Sir John Robison, Sec. R.S.E......................1832, 1836, 1841, 1842.
P. M. Roget, M.D., Sec. R.S., F.G.S., &c...1834—1837, 1841, 1842.
Lieut.-Colonel Sabine ....1838.
Lord Sandon ....1840.
Rev. Professor Sedgwick, M.A., F.R.S. ......1842, 1843.
Rev. William Scoresby, B.D., F.R.SS.L. & E.1842.
H. E. Strickland, Esq., F.G.S......................1840—1842.
Lieut.-Col.W. H. Sykes, F.R.S., F.L.S., &c.1837—1839, 1842—1843.
H. Fox Talbot, Esq., F.R.S..........................1840.
Rev. J. J. Tayler, B.A., Manchester ....1832.
William Thompson, F.L.S. ....1843.
Professor Traill, M.D. ....1832, 1833.
N. A. Vigors, M.P., D.C.L., F.S.A., F.L.S.1832, 1836, 1840.
James Walker, Esq., P.S.C.E......................1840.
Captain Washington, R.N. ....1838, 1839, 1840.
Professor Wheatstone ....1838—1843.
Rev.W.Whewell,F.R.S.,MasterofT.C.Camb.1838, 1839, 1842, 1843.
C. J. B. Williams, M.D. ....1842, 1843.
Rev. Prof. Willis, M.A., F.R.S. ....1842.
William Yarrell, F.L.S..................................1833—1836.
James Yates, Esq., M.A., F.R.S...................1842.

Secretaries to the Council. { Edward Turner, M.D., F.R.SS. L. & E. 1832—1836.
James Yates, F.R.S., F.L.S., F.G.S. 1831—1840. }

OFFICERS OF SECTIONAL COMMITTEES AT THE CORK MEETING.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

President.—Professor M'Cullagh, M.R.I.A.

Vice-Presidents.—Professor Lloyd, F.R.S., M.R.I.A. The Rev. Dr. Peacock, Dean of Ely, F.R.S. W. Snow Harris, F.R.S.

Secretaries.—Professor Stevelly, M.A. John Nott.

SECTION B.—CHEMISTRY AND MINERALOGY;
(including their applications to Agriculture and the Arts.)

President.—Professor Apjohn, M.R.I.A.

Vice-Presidents.—Marquis of Northampton, Pres. R.S. Professor Kane, M.R.I.A.

Secretaries.—Robert Hunt, Sec. R. C. Polytechnic Society. Dr. Sweeny.

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President.—Richard E. Griffith, F.R.S., M.R.I.A.

President for Geography.—R. I. Murchison, F.R.S.

Vice-Presidents.—Wm. Hopkins, F.R.S. Charles Lyell, F.R.S. John Taylor, F.R.S.

Secretaries.—Francis M. Jennings, M.R.I.A., F.G.S. H. E. Strickland, F.G.S.

SECTION D.—ZOOLOGY AND BOTANY.

President.—William Thompson, F.L.S.

Vice-Presidents.—Robert Ball, M.R.I.A. Professor Owen, F.R.S. Professor E. Forbes, F.L.S. C. C. Babington, F.L.S.

Secretaries.—Edwin Lankester, M.D., F.L.S. Robert Patterson. George J. Allman, M.B.

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Vice-Presidents.—William Bullen, M.D. Charles P. Croker, M.D. A. H. Callanan, M.D. Christopher Bull, M.D.

Secretaries.—John Popham, M.D. Richard S. Sargent, M.D.

SECTION F.—STATISTICS.

President.—Sir C. Lemon, Bart., M.P.

Vice-Presidents.—Major N. Ludlow Beamish, F.R.S. Sir W. Chatterton.

Secretaries.—W. Cooke Taylor, LL.D. D. Bullen, M.D.

SECTION G.—MECHANICAL SCIENCE.

President.—Professor John Macneill, M.R.I.A.

Vice-Presidents.—John Taylor, F.R.S. F. G. Bergen, Esq. Sir Thomas Deane, Knt.

Secretaries.—James Thomson, F.R.S.E. Robert Mallet, C.E.

CORRESPONDING MEMBERS.

Professor Agassiz, Neufchatel. M. Arago, Secretary of the Institute, Paris. A. D. Bache, Philadelphia. Professor Berzelius, Stockholm. Professor Bessel, Königsberg. Professor H. von Boguslawski, Breslau. Professor Braschmann, Moscow. Professor De la Rive, Geneva. Professor Dumas, Paris. Professor Ehrenberg, Berlin. Professor Encke, Berlin. Dr. A. Erman, Berlin. M. Frisiani, Astronomer, Milan. Baron Alexander von Humboldt, Berlin. Professor Henry, Princeton, U. S. M. Jacobi, St. Petersburgh. Professor Jacobi, Königsberg. Dr. Lamont, Munich. Professor Liebig, Giessen. Professor Link, Berlin. Dr. Langberg, Christiania. Professor Œrsted, Copenhagen. M. Otto, Breslau. Jean Plana, Astronomer Royal, Turin. M. Quetelet, Brussels. Professor C. Ritter, Berlin. Professor Schumacher, Altona. Professor Wartmann, Lausanne.

TREASURER'S ACCOUNT from

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance in hand from last year's Account				538	14	6
LifeCompositions received at theManchesterMeeting, and since	869	0	0			
Annual Subscriptions......Ditto......Ditto......Ditto	868	0	0			
				1737	0	0
Compositions for Books (future publications)	208	0	0			
Moieties of £5 Compositions Refunded	15	10	0			
				192	10	0
Dividends on £5500 in 3 per cent. Consols, 18 months, to January 1843				247	10	0
Received on account of Sale of Reports, viz.						
1st vol., 2nd Edition	7	4	8			
2nd vol.	6	18	5			
3rd vol.	7	10	0			
4th vol.	8	2	0			
5th vol.	7	17	11			
6th vol.	10	7	11			
7th vol.	12	9	0			
8th vol.	16	4	11			
9th vol.	31	10	0			
10th vol.	57	8	5			
11th vol.	11	11	0			
Lithographs	2	2	0			
				179	15	3
Received for Ladies' Tickets at the Manchester Meeting				331	0	0
Ditto for Tickets to the Sections only..........ditto				33	0	0
Ditto from Bankers at Manchester, Interest on Cash				11	14	7
				£3271	4	4

ROBERT HUTTON, } Auditors.
JAMES HEYWOOD, }

23rd of June 1842 to the 14th of August 1843.

PAYMENTS.

	£ s. d.	£ s. d.	£ s. d.
Sundry Disbursements by Treasurer and Local Treasurers, including the expenses of the Manchester Meeting, Advertising, and Sundry Printing			328 8 10
Paid for printing, &c. the Eleventh Report		438 0 9	
Paid on account of Engraving for Twelfth Report		7 19 6	
			446 0 3
Paid Salaries to Assistant General Secretary, Accountant, &c.			435 0 0
Paid on account of Grants to Committees for Scientific purposes, viz.—			
Revision of the Nomenclature of Stars 1842		2 0 0	
Reductions of Stars, British Association Catalogue ,,		25 0 0	
Anomalous Tides, Frith of Forth.................. ,,		120 0 0	
Hourly Meteorological Observations at Kingussie and Inverness 1842		47 12 8	
Hourly Meteorological Observations at Kingussie and Inverness 1841		30 0 0	
Meteorological Observations at Plymouth ...... ,,		5 0 0	
Do. 1842		50 0 0	
Do. Whewell's Anemometer Do. .... ,,		10 0 0	
Do. Osler's ....Do.......Do. .... ,,		20 0 0	
Reduction of Meteorological Observations ...... ,,		30 0 0	
Meteorological Instruments and Gratuities......1841		39 6 0	
Construction of Anemometer at Inverness ...... ,,		56 12 2	
Magnetic Co-operation........ .... ,,		10 8 10	
Meteorological Recorder for Kew Observatory ,,		50 0 0	
Action of Gases on Light .... ,,		13 3 0	
Do...1842		5 13 1	
Establishment at Kew Observatory, Wages, &c......	38 7 6		
Do. Repairs, Furniture, and Sundries	94 17 1		
		133 4 7	
Experiments by Captive Balloons 1842		81 8 0	
Oxidation of the Rails of Railways .... ,,		20 0 0	
Publication of Report on Fossil Reptiles......... ,,		40 0 0	
Coloured Drawings of Railway Sections .... ,,		147 18 3	
Registration of Eathquake Shocks .... ,,		30 0 0	
Uncovering Lower Red Sandstone near Manchester ,,		4 4 6	
Report on Zoological Nomenclature .... ,,		10 0 0	
Vegetative Power of Seeds .... ,,		5 3 8	
Marine Testacea, (Habits of) .... ,,		10 0 0	
Marine Zoology.. ,,		10 0 0	
Do. 1841		2 14 11	
Preparation of Report on British Fossil Mammalia 1842		100 0 0	
Physiological operations of Medicinal Agents... ,,		20 0 0	
Vital Statistics 1841		36 5 8	
Additional Experiments on the Forms of Vessels ,,		70 0 0	
Do. 1842		100 0 0	
Reduction of Observations ....Do.......... ,,		100 0 0	
Morin's Instrument and Constant Indicator ... ,,		69 14 10	
Experiments on the Strength of Materials ...... ,,		60 0 0	
			1565 10 2
Balance in the Bankers' hands		432 16 11	
Do. General Treasurer's hands		40 12 5	
Do. Local Treasurers' hands		22 15 9	
			496 5 1
			£3271 4 4

The following Reports on the Progress and Desiderata of different branches of Science have been drawn up at the request of the Association, and printed in its Transactions.

1831–32.

On the progress of Astronomy during the present century, by G. B. Airy, M.A., Astronomer Royal.

On the state of our knowledge respecting Tides, by J. W. Lubbock, M.A., Vice-President of the Royal Society.

On the recent progress and present state of Meteorology, by James D. Forbes, F.R.S., Professor of Natural Philosophy, Edinburgh.

On the present state of our knowledge of the science of Radiant Heat, by the Rev. Baden Powell, M.A., F.R.S., Savilian Professor of Geometry, Oxford.

On Thermo-electricity, by the Rev. James Cumming, M.A., F.R.S., Professor of Chemistry, Cambridge.

On the recent progress of Optics, by Sir David Brewster, K.C.G., LL.D., F.R.S., &c.

On the recent progress and present state of Mineralogy, by the Rev. William Whewell, M.A., F.R.S.

On the progress, actual state, and ulterior prospects of Geology, by the Rev. William Conybeare, M.A., F.R.S., V.P.G.S., &c.

On the recent progress and present state of Chemical Science, by J. F. W. Johnston, A.M., Professor of Chemistry, Durham.

On the application of Philological and Physical researches to the History of the Human species, by J. C. Prichard, M.D., F.R.S., &c.

1833.

On the advances which have recently been made in certain branches of Analysis, by the Rev. G. Peacock, M.A., F.R.S., &c.

On the present state of the Analytical Theory of Hydrostatics and Hydrodynamics, by the Rev. John Challis, M.A., F.R.S., &c.

On the state of our knowledge of Hydraulics, considered as a branch of Engineering, by George Rennie, F.R.S., &c. (Parts I. and II.)

On the state of our knowledge respecting the Magnetism of the Earth, by S. H. Christie, M.A., F.R.S., Professor of Mathematics, Woolwich.

On the state of our knowledge of the Strength of Materials, by Peter Barlow, F.R.S.

On the state of our knowledge respecting Mineral Veins, by John Taylor, F.R.S., Treasurer G.S., &c.

On the Physiology of the Nervous System, by William Charles Henry, M.D.

On the recent progress of Physiological Botany, by John Lindley, F.R.S., Professor of Botany in the University of London.

1834.

On the Geology of North America, by H. D. Rogers, F.G.S.

On the philosophy of Contagion, by W. Henry, M.D., F.R.S.

On the state of Physiological Knowledge, by the Rev. Wm. Clark, M.D., F.G.S., Professor of Anatomy, Cambridge.

On the state and progress of Zoology, by the Rev. Leonard Jenyns, M.A., F.L.S., &c.

On the theories of Capillary Attraction, and of the Propagation of Sound as affected by the Development of Heat, by the Rev. John Challis, M.A., F.R.S., &c.

On the state of the science of Physical Optics, by the Rev. H. Lloyd, M.A., Professor of Natural Philosophy, Dublin.

1835.

On the state of our knowledge respecting the application of Mathematical and Dynamical principles to Magnetism, Electricity, Heat, &c., by the Rev. William Whewell, M.A., F.R.S.

On Hansteen's researches in Magnetism, by Captain Sabine, F.R.S.

On the state of Mathematical and Physical Science in Belgium, by M. Quetelet, Director of the Observatory, Brussels.

1836.

On the present state of our knowledge with respect to Mineral and Thermal Waters, by Charles Daubeny, M.D., F.R.S., M.R.I.A., &c., Professor of Chemistry and of Botany, Oxford.

On North American Zoology, by John Richardson, M.D., F.R.S., &c.

Supplementary Report on the Mathematical Theory of Fluids, by the Rev. J. Challis, Plumian Professor of Astronomy in the University of Cambridge.

1837.

On the variations of the Magnetic Intensity observed at different points of the Earth's surface, by Major Edward Sabine, R.A., F.R.S.

On the various modes of Printing for the use of the Blind, by the Rev. William Taylor, F.R.S.

On the present state of our knowledge in regard to Dimorphous Bodies, by Professor Johnston, F.R.S.

On the Statistics of the Four Collectorates of Dukhun, under the British Government, by Col. Sykes, F.R.S.

1838.

Appendix to Report on the variations of Magnetic Intensity, by Major Edward Sabine, R.A., F.R.S.

1839.

Report on the present state of our knowledge of Refractive Indices for the Standard Rays of the Solar Spectrum in different media, by the Rev. Baden Powell, M.A., F.R.S., F.G.S., F.R.Ast.S., Savilian Professor of Geometry, Oxford.

Report on the distribution of Pulmoniferous Mollusca in the British Isles, by Edward Forbes, M.W.S., For. Sec. B.S.

Report on British Fossil Reptiles, Part I., by Richard Owen, Esq., F.R.S., F.G.S., &c.

1840.

Report on the recent progress of discovery relative to Radiant Heat, supplementary to a former Report on the same subject inserted in the first volume of the Reports of the British Association for the Advancement of Science, by the Rev. Baden Powell, M.A., F.R.S., F.R.Ast.S., F.G.S., Savilian Professor of Geometry in the University of Oxford.

Supplementary Report on Meteorology, by James D. Forbes, Esq., F.R.S., Sec. R.S. Ed., Professor of Natural Philosophy in the University of Edinburgh.

1841.

Report on the conduction of Heat, by Professor Kelland, F.R.S., &c.

Report on the state of our knowledge of Fossil Reptiles, Part II., by Professor R. Owen, F.R.S.

1842.

Abstract of Report of Professor Liebig on Organic Chemistry applied to Physiology and Pathology, by Lyon Playfair, M.D.

Report on the Ichthyology of New Zealand, by John Richardson, M.D., F.R.S.

On the Fossil Fishes of the Old Red Sandstone, by Professor Agassiz.

Report on British Fossil Mammalia (Part I.), by Professor Owen.

1843.

Synoptical Table of British Fossil Fishes, by Professor Agassiz.

Report on British Fossil Mammalia (Part II.), by Professor Owen.

Report on the Fauna of Ireland: Div. Invertebrata. Drawn up, at the request of the British Association, by William Thompson, Esq., President of the Natural History and Philosophical Society of Belfast.

The following Reports of Researches undertaken at the request of the Association have been published in its Transactions, viz.

1835.

On the comparative measurement of the Aberdeen Standard Scale, by Francis Baily, Treasurer R.S., &c.

On Impact upon Beams, by Eaton Hodgkinson.

Observations on the Direction and Intensity of the Terrestrial Magnetic Force in Ireland, by the Rev. H. Lloyd, Capt. Sabine, and Capt. J. C. Ross.

On the phænomena usually referred to the Radiation of Heat, by H. Hudson, M.D.

Experiments on Rain at different Elevations, by Wm. Gray, jun., and Professor Phillips (Reporter).

Hourly Observations of the Thermometer at Plymouth, by W. S. Harris.

On the Infra-orbital Cavities in Deers and Antelopes, by A. Jacob, M.D.

On the Effects of Acrid Poisons, by T. Hodgkin, M.D.

On the Motions and Sounds of the Heart, by the Dublin Sub-Committee.

On the Registration of Deaths, by the Edinburgh Sub-Committee.

1836.

Observations on the Direction and Intensity of the Terrestrial Magnetic Force in Scotland, by Major Edward Sabine, R.A., F.R.S., &c.

Comparative view of the more remarkable Plants which characterize the Neighbourhood of Dublin, the Neighbourhood of Edinburgh, and the South-west of Scotland, &c.; drawn up for the British Association by J. T. Mackay, M.R.I.A., A.L.S., &c.; assisted by Robert Graham, Esq., M.D., Professor of Botany in the University of Edinburgh.

Report of the London Sub-Committee of the Medical Section of the British Association on the Motions and Sounds of the Heart.

Report of the Dublin Committee on the Pathology of the Brain and Nervous System.

Account of the Recent Discussions of Observations of the Tides which have been obtained by means of the grant of money which was placed at the disposal of the Author for that purpose at the last meeting of the Association, by J. W. Lubbock, Esq.

Observations for determining the Refractive Indices for the Standard Rays of the Solar Spectrum in various media, by the Rev. Baden Powell, M.A., F.R.S., Savilian Professor of Geometry in the University of Oxford.

Provisional Report on the Communication between the Arteries and Absorbents, on the part of the London Committee, by Dr. Hodgkin.

Report of Experiments on Subterranean Temperature, under the direction of a Committee, consisting of Professor Forbes, Mr. W. S. Harris, Professor Powell, Lieut.-Colonel Sykes, and Professor Phillips (Reporter).

Inquiry into the validity of a method recently proposed by George B. Jerrard, Esq., for Transforming and Resolving Equations of Elevated Degrees; undertaken, at the request of the Association, by Professor Sir W. R. Hamilton.

1837.

Account of the Discussions of Observations of the Tides which have been obtained by means of the grant of money which was placed at the disposal of the Author for that purpose at the last Meeting of the Association, by J. W. Lubbock, Esq., F.R.S.

On the difference between the Composition of Cast Iron produced by the Cold and the Hot Blast, by Thomas Thomson, M.D., F.R.SS. L. & E., &c., Professor of Chemistry, Glasgow.

On the Determination of the Constant of Nutation by the Greenwich Observations, made as commanded by the British Association, by the Rev. T. R. Robinson, D.D.

On some Experiments on the Electricity of Metallic Veins, and the Temperature of Mines, by Robert Were Fox.

Provisional Report of the Committee of the Medical Section of the British Association, appointed to investigate the Composition of Secretions, and the Organs producing them.

Report from the Committee for inquiring into the Analysis of the Glands, &c. of the Human Body, by G. O. Rees, M.D., F.G.S.

Second Report of the London Sub-Committee of the Medical Section of the British Association, on the Motions and Sounds of the Heart.

Report from the Committee for making experiments on the Growth of Plants under Glass, and without any free communication with the outward air, on the plan of Mr. N. I. Ward of London.

Report of the Committee on Waves, appointed by the British Association at Bristol in 1836, and consisting of Sir John Robison, K.H., Secretary of the Royal Society of Edinburgh, and John Scott Russell, Esq., M.A., F.R.S. Edin. (Reporter).

On the Relative Strength and other mechanical Properties of Cast Iron obtained by Hot and Cold Blast, by Eaton Hodgkinson, Esq.

On the Strength and other Properties of Iron obtained from the Hot and Cold Blast, by W. Fairbairn, Esq.

1838.

Account of a Level Line, measured from the Bristol Channel to the English Channel, during the year 1837–38, by Mr. Bunt, under the Direction of a Committee of the British Association. Drawn up by the Rev. W. Whewell, F.R.S., one of the Committee.

A Memoir on the Magnetic Isoclinal and Isodynamic Lines in the British Islands, from observations by Professors Humphrey Lloyd and John Phillips, Robert Were Fox, Esq., Captain James Clark Ross, R.N., and Major Edward Sabine, R.A., by Major Edward Sabine, R.A., F.R.S.

First Report on the Determination of the Mean Numerical Values of Railway Constants, by Dionysius Lardner, LL.D., F.R.S., &c.

First Report upon Experiments instituted at the request of the British Association, upon the Action of Sea and River Water, whether clear or foul, and at various temperatures, upon Cast and Wrought Iron, by Robert Mallet, M.R.I.A., Ass. Ins. C.E.

Notice of Experiments in progress, at the desire of the British Association, on the Action of a Heat of 212° Fahr., when long continued, on Inorganic and Organic Substances, by Robert Mallet, M.R.I.A.

Experiments on the ultimate Transverse Strength of Cast Iron made at

Arigna Works, Co. Leitrim, Ireland, at Messrs. Bramah and Robinson's, 29th May, 1837.

Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

1839.

Report on the application of the sum assigned for Tide Calculations to Mr. Whewell, in a Letter from T. G. Bunt, Esq., Bristol.

Notice of Determination of the Arc of Longitude between the Observatories of Armagh and Dublin, by the Rev. T. R. Robinson, D.D., &c.

Report of some Galvanic Experiments to determine the existence or non-existence of Electrical Currents among Stratified Rocks, particularly those of the Mountain Limestone formation, constituting the Lead Measures of Alston Moor, by H. L. Pattinson, Esq.

Report respecting the two series of Hourly Meteorological Observations kept in Scotland at the expense of the British Association, by Sir David Brewster, K.H., LL.D., F.R.SS. L. and E.

Report on the subject of a series of Resolutions adopted by the British Association at their Meeting in August 1838, at Newcastle.

Third Report on the Progress of the Hourly Meteorological Register at the Plymouth Dockyard, Devonport, by W. Snow Harris, Esq., F.R.S.

1840.

Report on Professor Whewell's Anemometer, now in operation at Plymouth, by W. Snow Harris, Esq., F.R.S., &c.

Report on the Motions and Sounds of the Heart, by the London Committee of the British Association for 1839–40.

An Account of Researches in Electro-Chemistry, by Professor Schönbein of Basle.

Second Report upon the Action of Air and Water, whether fresh or salt, clear or foul, and at various temperatures, upon Cast Iron, Wrought Iron, and Steel, by Robert Mallet, M.R.I.A., Ass. Ins. C.E.

Report on the Observations recorded during the Years 1837, 1838, 1839, and 1840, by the Self-registering Anemometer erected at the Philosophical Institution, Birmingham, by A. Follett Osler, Esq.

Report respecting the two series of Hourly Meteorological Observations kept at Inverness and Kingussie, at the Expense of the British Association, from Nov. 1st, 1838, to Nov. 1st, 1839, by Sir David Brewster, K.H., F.R.S., &c.

Report on the Fauna of Ireland: Div. *Vertebrata*. Drawn up, at the request of the British Association, by William Thompson, Esq. (Vice-Pres. Nat. Hist. Society of Belfast), one of the Committee appointed for that purpose.

Report of Experiments on the Physiology of the Lungs and Air-tubes, by Charles J. B. Williams, M.D., F.R.S.

Report of the Committee appointed to try Experiments on the Preservation of Animal and Vegetable Substances, by the Rev. J. S. Henslow, F.L.S.

1841.

On the Tides of Leith, by the Rev. Professor Whewell, including a communication by D. Ross, Esq.

On the Tides of Bristol, by the Rev. Professor Whewell, including a communication by T. G. Bunt, Esq.

On Whewell's Anemometer, by W. S. Harris, Esq.

On the Nomenclature of Stars, by Sir John Herschel.

On the Registration of Earthquakes, by D. Milne, Esq.

On Varieties of the Human Race, by T. Hodgkin, M.D.

On Skeleton Maps for registering the geographical distribution of Animals or Plants, by — Brand, Esq.

On the Vegetative Power of Seeds, by H. E. Strickland, Esq.

On Acrid Poisons, by Dr. Roupell.

Supplementary Report on Waves, by J. S. Russell, Esq.

On the Forms of Ships, by J. S. Russell, Esq.

On the Progress of Magnetical and Meteorological Observations, by Sir John Herschel.

On Railway Constants, by Dr. Lardner.

On Railway Constants, by E. Woods, Esq.

On the Constant Indicator, by the Rev. Professor Moseley.

1842.

On the Progress of simultaneous Magnetical and Meteorological Observations, by Sir John Herschel.

On the Meteorological Observations made at Plymouth during the past year, by William Snow Harris, F.R.S.

On the Growth and Vitality of Seeds, by H. E. Strickland, F.G.S.

Reports of Committee on Railway Sections, by Rev. Dr. Buckland and Mr. Vignoles.

On the Preservation of Animal and Vegetable Substances; by C. C. Babington, F.L.S.

On the Influence of Light on the Germination of Seeds and the Growth of Plants, by Robert Hunt.

On the Strength of Iron, by Wm. Fairbairn.

Second Report of the Committee for registering Earthquakes, by David Milne, Esq.

On the Constant Indicator, by Professor Moseley.

On the Form of Ships, by John Scott Russell, M.A.

On Zoological Nomenclature, by H. E. Strickland, F.G.S.

On Vital Statistics, by Colonel Sykes, and the Committee on that subject.

Provisional Reports.

1843.

Third Report on the Action of Air and Water on Iron and Steel, by R. Mallet, M.R.I.A.

Report of Committee for Simultaneous Magnetic and Meteorological Cooperation.

Report of Committee for Experiments on Steam Engines.

Report of Committee for Experiments on the Vitality of Seeds.

Report on Tides of Frith of Forth and East Coast of Scotland, by J. S. Russell, M.A.

Report of Committee on the Form of Ships.

Report on the Physiological Action of Medicines, by J. Blake, M.R.C.S.

Report of Committee on Zoological Nomenclature.

Report of Committee on Earthquakes.

Report of Committee on Balloons.

Report of Committee on Scientific Memoirs.

Report on Marine Testacea, by C. W. Peach.

Report on the Mollusca and Radiata of the Ægean Sea, by Professor Forbes.

Report of the Excavation at Collyhurst near Manchester, by E. W. Binney.

Provisional Reports.

Concluding Report of Railroad Section Committee.

Recommendations adopted by the General Committee at the Cork Meeting in August 1843.

Resolved, on the motion of the Rev. Dr. Robinson, seconded by the Marquis of Northampton. That the British Association for the Advancement of Science return their thanks to Her Majesty's Government for the liberal manner in which they have granted assistance to the Association, for publishing Catalogues of Stars, by placing £1000 at their disposal for that purpose.

Resolved,—That the thanks of the British Association for the Advancement of Science be given to the Lord Lieutenant of Ireland for the early communication of Copies of the recent Census, presented to the Association; together with a strong expression of their approbation of the form in which the same is constructed, as a model for similar works.

That an application be made on the part of the British Association for the Advancement of Science, to the Master-General of the Ordnance, entreating his assistance in the Experiments with Captive Balloons. A Committee, consisting of the Marquis of Northampton, Lord Adare, and the Dean of Ely, to make the application.

That application be made to Government to give its aid in the publication of Professor E. Forbes's Researches in the Ægean Sea (on the same plan as the publications of Mr. Darwin, Dr. Smith, and Captain Belcher), those Researches having been made while he was engaged as Naturalist in the Government Hydrographical Survey in the Mediterranean.

Resolved,—That application be made to Her Majesty's Government for the insertion of *Contour Lines* of Elevation on the Ordnance Maps of Ireland, such lines being of great value for engineering, mining, geological and mechanical purposes: and that a Committee, consisting of the Earl of Rosse, the Marquis of Northampton, and John Taylor, Esq., be requested to make the application.

Publication of the Report on the Forms of Ships. That the Committee, consisting of the Dean of Ely, John MacNeill, Esq., Col. Sabine, and John Taylor, Esq., be requested to examine and consider the matter contained in the Report on the Form of Ships, and report upon the same, with a view to the publication of the whole or such parts of the same as to them may seem advisable: and that the Committee be requested further to consider and report upon any mode by which a publication, such as they may judge fit to be made, may be accomplished.

That it appears to the Committee highly desirable for the improvement of Science and Art in the City of Cork, and its neighbourhood, that the Royal Cork Institution should be restored to a state of efficiency; and that the officers of the Association be requested to support an application to Her Majesty's Government, for such assistance as may be necessary for that purpose.

Recommendations for Reports and Researches not involving Grants of Money.

That the Committee for revising the Nomenclature of Stars, consisting of Sir John Herschel, the Rev. W. Whewell, and Mr. Baily, be re-appointed.

That Professor Bache be requested to proceed with his Report on American Meteorology, and if possible, to present it at the next Meeting of the Association.

That applications be made—

To Mr. Airy, requesting him to furnish the Second Report on the progress of Astronomy, if possible, by the next Meeting of the Association.

To Professor Wheatstone for his Report on Vision, to be presented, if possible, at the next Meeting.

To Mr. Hodgkinson for his Report on the Resistance of the Atmosphere, to be presented, if possible, at the next Meeting of the Association.

To Professor Kelland for his Report on the Undulations of Fluid and Elastic Media, to be presented, if possible, at the next Meeting of the Association.

To Mr. Fox Talbot for his Report on Photography and its Applications, to be presented, if possible, at the next Meeting of the Association.

To Professor Phillips for his Report on the Structure and Colours of Clouds, to be presented, if possible, at the next Meeting of the Association.

To Dr. Lloyd for his second Report on Physical Optics, to be presented, if possible, at the next Meeting of the Association.

To Dr. Richardson for a Report on the State of our Knowledge of the Fishes of the Chinese Seas.

To Mr. H. E. Strickland for a Report on the present State of our Knowledge of Ornithology.

To Mr. Blackwall to enlarge his Report on the Palpi of Araneidea, so as to include in a condensed form a notice of the Habits and Structure of the entire tribe.

To Mr. Alder and Mr. Hancock for a Report on the British Nudibranchiate Mollusca.

To Mr. Blake for a Report of his Researches on the Physiological Action of Medicines.

That Mr. Fairbairn, Mr. Houldsworth, Mr. Hodgkinson, and Mr. Buck, be requested to continue their investigations on the Consumption of Fuel and the Prevention of Smoke.

Recommendations of Special Researches in Science, involving Grants of Money.

MATHEMATICAL AND PHYSICAL SCIENCE.

That Sir David Brewster be requested to continue till Nov. 1, 1843, the hourly observations on the Thermometer, Barometer and Anemometer, and that a sum not exceeding 12*l.* be placed at the disposal of the Council of the British Association for that purpose.

That Mr. William Snow Harris be requested to complete the Meteorological Observations at Plymouth, with 35*l.* at his disposal for the purpose.

That a Committee be appointed, consisting of Dr. Robinson, Col. Sabine, and Mr. Wheatstone, with 100*l.* at their disposal for the purpose of conducting experiments with Captive Balloons, on the Physical Constitution of the Atmosphere.

That a Committee be appointed, consisting of Sir John Herschel, Dr. Whewell, The Dean of Ely, Professor Lloyd, and Colonel Sabine, with 50*l.* at their disposal, for the purpose of Magnetic and Meteorological co-operation,—and that this Committee be authorized to superintend the reduction of Meteorological Observations formerly conducted by Sir J. Herschel.

That Sir D. Brewster be requested to investigate the action of different bodies on the Spectrum, with 10*l.* at his disposal for the purpose.

That a Committee be appointed, consisting of Colonel Sabine, Dr. Robinson, Sir John Herschel, Professor Wheatstone, Professor Owen, Professor T. Graham, Professor Miller, and Sir William Jardine, with 20*l.* at their disposal for the purpose of superintending the translation and publication of Scientific Memoirs.

That a Committee be appointed, consisting of Mr. Baily, and Dr. Robinson, with 650*l.* at their disposal for the purpose of publishing the British Association Catalogue of Stars, (500 copies).

That a Committee be appointed, consisting of Sir Thomas Brisbane, and Mr. J. S. Russell, with 100*l.* at their disposal, for the purpose of completing the Observations on Tides on the East coast of Scotland.

That a Committee be appointed, consisting of Professor Wheatstone, and Colonel Sabine, with 30*l.* at their disposal for the purpose of experimenting on Subterranean Temperature.

KEW OBSERVATORY.

That the sum of 200*l.* be placed at the disposal of the Council for the purpose of maintaining the establishment in Kew Observatory.

CHEMICAL SCIENCE.

That a Committee be re-appointed, consisting of Dr. Kane, Dr. Schunk, and Dr. Playfair, with 10*l.* at their disposal for the purpose of examining the History of Colouring Matters.

That a Committee be re-appointed, consisting of Dr. Kane, Dr. Schunk, and Dr. Playfair, with 10*l.* at their disposal for the purpose of Inquiries into the Chemical History of Tannin.

That a Committee be appointed, consisting of Mr. R. W. Fox, and Mr. R. Hunt, with 10*l.* at their disposal for the purpose of continuing Researches on the Influence of Light upon Plants.

GEOLOGICAL SCIENCE.

That Mr. Oldham be requested to undertake experiments on Subterranean Temperature in Ireland, with 10*l.* at his disposal for the purpose.

That a Committee be appointed, consisting of the Marquis of Northampton, Dr. Buckland, Mr. Murchison, Mr. John Taylor, Sir H. T. De la Beche, and Mr. Vignoles, with 100*l.* at their disposal for the purpose of making geological Sections of Railway Cuttings.

That a Committee be appointed, consisting of Professor Owen, Sir Philip Egerton, Dr. Buckland, and Mr. Murchison, with 100*l.* at their disposal for the purpose of advancing our knowledge of the Fossil Fishes of the London Clay, and other Eocene Formations of Great Britain.

That a Committee be appointed, consisting of Rev. W. Whewell, Sir H. T. De la Beche, and Professor Phillips, with 20*l.* at their disposal for the purpose of examining the state of the reference Level Marks on the line surveyed by Mr. Bunt in Somerset and Devon, and of restoring them where necessary.

That a Committee be appointed, consisting of Mr. David Milne, and Mr. Duncan Maclaren, with 20*l.* at their disposal for the purpose of establishing standard Level Marks on such parts of the Coasts of Scotland as they may think fit, with a view of ascertaining the Oscillations of the Land, particularly in reference to the lines of Earthquake Shocks.

GEOLOGY AND ZOOLOGY.

That Dr. Carpenter be requested to draw up a Report on the Minute Structure of Recent and Fossil Shells by means of the Microscope, with 20*l.* at his disposal for the purpose.

BOTANY AND ZOOLOGY.

That a Committee be appointed, consisting of Mr. H. E. Strickland, Dr.

Daubeny, Professor Lindley, Mr. Henslow, Mr. Babington, Professor Balfour, Mr. Mackay, and Mr. D. Moore, with 15*l.* at their disposal for the purpose of conducting Experiments on the Vitality of Seeds.

That a Committee be appointed, consisting of Sir W. Jardine, Mr. Yarrell, and Dr. Lankester, with 25*l.* at their disposal for the purpose of investigating the Exotic forms of the Anoplura.

That Capt. Portlock be requested to Report on the Marine Zoology of Corfu, with 10*l.* at his disposal for the purpose.

That a Committee be appointed, consisting of Dr. Daubeny, Mr. Babington, Mr. R. Ball, Professor Apjohn, and Professor Kane, with 10*l.* at their disposal for the purpose of investigating the Preservation of Animal and Vegetable Substances.

That a Committee be appointed, consisting of Professor Owen, Professor E. Forbes, Sir Charles Lemon, and Mr. Couch, with 10*l.* at their disposal for the purpose of enabling Mr. Peach to continue his researches on the Marine Zoology of Cornwall and Devon, especially on the development and preservation of Radiata and Mollusca.

That a Committee be appointed, consisting of Professor E. Forbes, Mr. Goodsir, Mr. Patterson, Mr. Thompson, Mr. Ball, Mr. Smith, and Mr. Couch, with 25*l.* at their disposal for the purpose of investigating, by means of the dredge, the Marine Zoology of Great Britain, the illustration of the Geographical distribution of Marine Animals and the accurate determination of the Fossils of the Pleiocene Period.

That a Committee be appointed, consisting of Dr. Hodgkin, Dr. Prichard, Professor Owen, Dr. H. Ware, Mr. J. E. Gray, Dr. Lankester, Dr. A. Smith, Mr. Strickland, Mr. Babington, Dr. Scowler, and Mr. Wilde, with 15*l.* at their disposal for the purpose of investigating the varieties of the Human Race.

MEDICAL SCIENCE.

That a Committee be appointed, consisting of Dr. Sharpey and Mr. Erichsen, with 10*l.* at their disposal for the purpose of conducting an experimental inquiry on the subject of Asphyxia.

MECHANICAL SCIENCE.

That Mr. J. S. Russell be requested to complete the discussion of the British Association Experiments on the Forms of Ships, with 100*l.* at his disposal for the purpose.

That Mr. Eaton Hodgkinson be requested to continue his experiments on the Strength of Materials and the changes which take place in their internal constitution, with 100*l.* at his disposal for the purpose.

That a Committee be appointed, consisting of Mr. Fairbairn, Mr. Nasmyth, Mr. Hodgkinson, and Mr. Lucas, with 50*l.* at their disposal for the purpose of completing the experimental investigations on the Changes in the internal Constitution of Metals arising from continual Vibration and Concussion.

GENERAL NOTICE.

Gentlemen engaged in scientific researches by desire of the British Association, are requested to observe that by a Resolution of the General Committee at the Manchester Meeting (1842), all Instruments, Papers, Drawings and other Property of the Association, are to be deposited in the Kew Observatory (lately placed by Her Majesty the Queen at the disposal of the Association), when not employed in carrying on Scientific Inquiries for the Association; and the Secretaries are instructed to adopt the necessary measures for carrying this resolution into effect.

Synopsis of Grants of Money appropriated to Scientific Objects by the General Committee, at the Cork Meeting, August 23, 1843, with the Name of the Member, who alone, or as the First of a Committee, is entitled to draw for the Money.

Mathematical and Physical Science.

	£	s.	d.
BREWSTER, Sir D.—For continuing hourly Meteorological Observations at Kingussie and Inverness	12	0	0
HARRIS, W. S.—For completing the Meteorological Observations at Plymouth	35	0	0
ROBINSON, Dr.—For conducting experiments with Captive Balloons	100	0	0
HERSCHEL, Sir J.—For Magnetic and Meteorological Co-operation	50	0	0
BREWSTER, Sir D.—For investigating the Action of different Bodies on the Spectrum	10	0	0
SABINE, Col.—For superintending the Translation and Publication of Scientific Memoirs	20	0	0
BAILY, FRANCIS, Esq.—For the Publication of the British Association Catalogue of Stars, (500 copies)	650	0	0
BRISBANE, Sir THOMAS—For completing the Observations on Tides of the East Coast of Scotland	100	0	0
WHEATSTONE, Professor—For experiments on Subterraneous Temperature	30	0	0
	£1007	0	0

Kew Observatory.

For maintaining the establishment in Kew Observatory	£200	0	0

Chemical Science.

KANE, Professor—For investigating the Chemical history of Colouring Substances	10	0	0
KANE, Professor—For inquiries into the Chemical history of Tannin	10	0	0
FOX, R. W. Esq.—For continuing Researches on the Influence of Light on Plants	10	0	0
	£30	0	0

Geological Science.

OLDHAM, ——, Esq.—For experiments on Subterraneous Temperature in Ireland	10	0	0
NORTHAMPTON, MARQUIS OF—For making Coloured Drawings of Railroad Cuttings	100	0	0
OWEN, Professor—For investigation of Fossil Fishes of the Lower Tertiary Strata	100	0	0
WHEWELL, Rev. W.—For completing level marks in Somerset and Devon	20	0	0
MILNE, DAVID, Esq.—For Establishing Standard Level Marks on the Coast of Scotland	20	0	0
	£250	0	0

Geology and Zoology.

	£	s.	d.
Carpenter, Dr.—For Researches into the Microscopic structure of Fossil and Recent Shells	£20	0	0

Botany and Zoology.

	£	s.	d.
Strickland, H. E., Esq.—For experiments on the Vitality of Seeds	15	0	0
Jardine, Sir W. Bart.—For researches on Exotic Anoplura	25	0	0
Portlock, Captain—For a Report on the Marine Zoology of Corfu	10	0	0
Daubeny, Dr.—For Investigating the Preservation of Animal and Vegetable Substances	10	0	0
Owen, Professor,—For Researches on the Marine Zoology of Cornwall and Devon by Mr. Peach	10	0	0
Forbes, Professor E.—For Researches on the Geographical Distribution of Marine Animals	25	0	0
Hodgkin, Dr.—For Inquiries into the varieties of the Human Race	15	0	0
	£110	0	0

Medical Science.

	£	s.	d.
Sharpey, Dr.—For Inquiries into Asphyxia	£10	0	0

Mechanical Science.

	£	s.	d.
Russell, J. S. Esq.—For completing the discussion of the *British Association* experiments on the Form of Ships	100	0	0
Hodgkinson, Eaton, Esq.—For experiments on the Strength of Materials	100	0	0
Fairbairn, W., Esq.—For experimental investigations on Changes in the internal Constitution of Metals	50	0	0
	£250	0	0
Total of Grants	£1877	0	0

General Statement of Sums which have been paid on Account of Grants for Scientific Purposes.

	£	s.	d.
1834.			
Tide Discussions	20	0	0
1835.			
Tide Discussions	62	0	0
British Fossil Ichthyology	105	0	0
	£167	0	0
1836.			
Tide Discussions	163	0	0
British Fossil Ichthyology	105	0	0
Thermometric Observations, &c.	50	0	0
Experiments on long-continued Heat	17	1	0
Rain Gauges	9	13	0
Carried forward	£344	14	0

	£	s.	d.
Brought forward	344	14	0
Refraction Experiments	15	0	0
Lunar Nutation	60	0	0
Thermometers	15	6	0
	£435	0	0
1837.			
Tide Discussions	284	1	0
Chemical Constants	24	13	6
Lunar Nutation	70	0	0
Observations on Waves	100	12	0
Tides at Bristol	150	0	0
Meteorology and Subterranean Temperature	89	5	0
Vitrification Experiments	150	0	0
Carried forward	£868	11	6

	£	s.	d.
Brought forward	868	11	6
Heart Experiments	8	4	6
Barometric Observations	30	0	0
Barometers	11	18	6
	£918	14	6
1838.			
Tide Discussions	29	0	0
British Fossil Fishes	100	0	0
Meteorological Observations and Anemometer (construction)	100	0	0
Cast Iron (strength of)	60	0	0
Animal and Vegetable Substances (preservation of)	19	1	10
Railway Constants	41	12	10
Bristol Tides	50	0	0
Growth of Plants	75	0	0
Mud in Rivers	3	6	6
Education Committee	50	0	0
Heart Experiments	5	3	0
Land and Sea Level	267	8	7
Subterranean Temperature	8	6	0
Steam-vessels	100	0	0
Meteorological Committee	31	9	5
Thermometers	16	4	0
	£956	12	2
1839.			
Fossil Ichthyology	110	0	0
Meteorological Observations at Plymouth	63	10	0
Mechanism of Waves	144	2	0
Bristol Tides	35	18	6
Meteorology and Subterranean Temperature	21	11	0
Vitrification Experiments	9	4	7
Cast Iron Experiments	100	0	0
Railway Constants	28	7	2
Land and Sea Level	274	1	4
Steam-vessels' Engines	100	0	0
Stars in Histoire Céleste	331	18	6
Stars in La Caille	11	0	0
Stars in R.A.S. Catalogue	6	16	6
Animal Secretions	10	10	0
Steam-engines in Cornwall	50	0	0
Atmospheric Air	16	1	0
Cast and Wrought Iron	40	0	0
Carried forward	£1353	0	7

	£	s.	d.
Brought forward	1353	0	7
Heat on Organic Bodies	3	0	0
Gases on Solar Spectrum	22	0	0
Hourly Meteorological Observations, Inverness and Kingussie	49	7	8
Fossil Reptiles	118	2	9
Mining Statistics	50	0	0
	£1595	11	0
1840.			
Bristol Tides	100	0	0
Subterranean Temperature	13	13	6
Heart Experiments	18	19	0
Lungs Experiments	8	13	0
Tide Discussions	50	0	0
Land and Sea Level	11	6	1
Stars (Histoire Céleste)	242	10	0
Stars (La Caille)	4	15	0
Stars (Catalogue)	264	0	0
Atmospheric Air	15	15	0
Water on Iron	10	0	0
Heat on Organic Bodies	7	0	0
Meteorological Observations	32	17	6
Foreign Scientific Memoirs	112	1	6
Working Population	100	0	0
School Statistics	50	0	0
Forms of Vessels	184	7	0
Chemical and Electrical Phænomena	40	0	0
Meteorological Observations at Plymouth	80	0	0
Magnetical Observations	185	13	0
	£1546	16	4
1841.			
Observations on Waves	30	0	0
Meteorology and Subterranean Temperature	8	8	0
Actinometers	10	0	0
Earthquake Shocks	17	7	0
Acrid Poisons	6	0	0
Veins and Absorbents	3	0	0
Mud in Rivers	5	0	0
Marine Zoology	15	12	8
Skeleton Maps	20	0	0
Mountain Barometers	6	18	6
Stars (Histoire Céleste)	185	0	0
Stars (La Caille)	79	5	0
Carried forward	£386	11	2

	£	s.	d.
Brought forward	386	11	2
Stars (Nomenclature of)	17	19	6
Stars (Catalogue of)	40	0	0
Water on Iron	50	0	0
Meteorological Observations at Inverness	20	0	0
Meteorological Observations (reduction of)	25	0	0
Fossil Reptiles	50	0	0
Foreign Memoirs	62	0	0
Railway Sections	38	1	6
Forms of Vessels	193	12	0
Meteorological Observations at Plymouth	55	0	0
Magnetical Observations	61	18	8
Fishes of the Old Red Sandstone	100	0	0
Tides at Leith	50	0	0
Anemometer at Edinburgh	69	1	10
Tabulating Observations	9	6	3
Races of Men	5	0	0
Radiate Animals	2	0	0
	£1235	10	11
1842.			
Dynamometric Instruments	113	11	2
Anopleura Britanniæ	52	12	0
Tides at Bristol	59	8	0
Gases on Light	30	14	7
Chronometers	26	17	6
Marine Zoology	1	5	0
British Fossil Mammalia	100	0	0
Statistics of Education	20	0	0
Marine Steam-vessels' Engines	28	0	0
Stars (Histoire Céleste)	59	0	0
Stars (British Association Catalogue of)	110	0	0
Railway Sections	161	10	0
British Belemnites	50	0	0
Fossil Reptiles (publication of Report)	210	0	0
Forms of Vessels	180	0	0
Galvanic Experiments on Rocks	5	8	6
Meteorological Experiments at Plymouth	68	0	0
Constant Indicator and Dynamometric Instruments	90	0	0
Carried forward	£1366	6	9

	£	s.	d.
Brought forward	1366	6	9
Force of Wind	10	0	0
Light on Growth of Seeds	8	0	0
Vital Statistics	50	0	0
Vegetative Power of Seeds	8	1	11
Questions on Human Race	7	9	0
	£1449	17	8
1843.			
Revision of the Nomenclature of Stars	2	0	0
Reductions of Stars, British Association Catalogue	25	0	0
Anomalous Tides, Frith of Forth	120	0	0
Hourly Meteorological Observations at Kingussie and Inverness	77	12	8
Meteorological Observations at Plymouth	55	0	0
Meteorological Whewell's Anemometer at Plymouth	10	0	0
Meteorological Observations Osler's Anemometer at Plymouth	20	0	0
Reduction of Meteorological Observations	30	0	0
Meteorological Instruments and Gratuities	39	6	0
Construction of Anemometer at Inverness	56	12	2
Magnetic Co-operation	10	8	10
Meteorological Recorder for Kew Observatory	50	0	0
Action of Gases on Light	18	16	1
Establishment at Kew Observatory, Wages, Repairs, Furniture, and Sundries	133	4	7
Experiments by Captive Balloons	81	8	0
Oxidations of the Rails of Railways	20	0	0
Publication of Report on Fossil Reptiles	40	0	0
Carried forward	£789	8	4

	£	s.	d.
Brought forward	789	8	4
Coloured Drawings of Railway Sections . .	147	18	3
Registration of Earthquake Shocks . . .	30	0	0
Uncovering Lower Red Sandstone near Manchester	4	4	6
Report on Zoological Nomenclature . . .	10	0	0
Vegetative Power of Seeds	5	3	8
Marine Testacea, (Habits of)	10	0	0
Marine Zoology . . .	10	0	0
Marine Zoology . . .	2	14	11
Preparation of Report			
Carried forward	£1009	9	8

	£	s.	d.
Brought forward	1009	9	8
on British Fossil Mammalia	100	0	0
Physiological operations of Medicinal Agents .	20	0	0
Vital Statistics	36	5	8
Additional Experiments on the Forms of Vessels	70	0	0
Additional Experiments on the Forms of Vessels	100	0	0
Reduction of Observations on the Forms of Vessels	100	0	0
Morin's Instrument and Constant Indicator. .	69	14	10
Experiments on the Strength of Materials	60	0	0
	£1565	10	2

Extracts from Resolutions of the General Committee.

Committees and individuals to whom grants of money for scientific purposes have been entrusted, are required to present to each following meeting of the Association a Report of the progress which has been made; with a statement of the sums which have been expended, and the balance which remains disposable on each grant.

Grants of pecuniary aid for scientific purposes from the funds of the Association expire at the ensuing meeting, unless it shall appear by a Report that the Recommendations have been acted on, or a continuation of them be ordered by the General Committee.

In each Committee, the Member first named is the person entitled to call on the Treasurer, John Taylor, Esq., 2 Duke Street, Adelphi, London, for such portion of the sum granted as may from time to time be required.

In grants of money to Committees, the Association does not contemplate the payment of personal expenses to the Members.

In all cases where additional grants of money are made for the continuation of Researches at the cost of the Association, the sum named shall be deemed to include as a part of the amount, the specified balance which may remain unpaid on the former grant for the same object.

On Thursday evening, August 17th, at 8 P.M., the President, the Right Hon. the Earl of Rosse, F.R.S., took the Chair in the Corn Exchange, Cork, and delivered an Address (see page xxix.).

On Saturday evening, August 19th, in the Corn Exchange, Professor Owen delivered a discourse on the Dinornis of New Zealand.

On Monday evening, August 21st, in the same Room, Professor Forbes stated the result of his recent Surveys of Distribution of Animal Life in the Ægean Sea.

On Wednesday, August 23rd, at 8 P.M., the Concluding General Meeting of the Association took place in the Corn Exchange, when Dr. Robinson delivered an account of the principles of construction employed in the Great Reflecting Telescopes of the President, the Earl of Rosse. A synoptical statement of the grants of money sanctioned at the Meeting was presented to the Members.

ADDRESS

BY

THE EARL OF ROSSE.

Gentlemen,—I am sure no one can feel more sensible of the kindness of my noble friend, in condescending to notice my very humble exertions in the cause of astronomical science, and no one more conscious that the compliment so flattering is undeserved, and, I must say, that I should be but too happy were it now in my power to resign into his abler hands those duties which have just devolved upon me; for in that case I am sure the Association would have nothing to desire. But as that is impossible, and as it has been of late the practice for those who have occupied the position in which I find myself most undeservedly placed, to offer a few observations on the objects of the Association at the first General Meeting, I feel I have no other course but to solicit most earnestly your kind indulgence. Such a request you would not perhaps consider unreasonable from any one who laboured under the embarrassment necessarily arising from the consciousness of his own inability adequately to discharge the duties entrusted to him, augmented, as it must be, tenfold, by that awe which it is impossible not to feel in the presence of men the most distinguished in the varied departments of human knowledge. But perhaps, in this instance, your kindness will allow there is an additional claim to your indulgence. This very embarrassing position is not of my own seeking. To have aspired to the high honour of presiding at one of your meetings, would have been an act of presumptuous vanity, which I never did, which I never could have contemplated. A communication from Manchester, announcing that the Association had actually made their selection, was the first intimation which reached me that my name had even been thought of. Under such circumstances, to have declined the honour, and to have shrunk from the responsibility, would, in my opinion, have been inconsistent with proper respect: it remained, therefore, but to endeavour to do the utmost, trusting that your kindness would overlook all omissions, and that the vigilance of the many most able men who guide the proceedings of the Association would detect and correct all important errors. But, however arduous the task, however painful the duty of addressing a meeting so constituted as this is, it is impossible not to participate in the gratification which all must feel in seeing so many men of eminence assembled to assist each other in promoting objects of such deep and general interest. The man of the world who, busied in the changing scenes of life, watches with fixed attention the actions of men, while he occasionally perhaps casts a passing glance at science as it happens to present to him some new wonder—he cannot fail to look with surprise, and, I may add, with gratification, at a meeting so large (and in this country too), from which politics are altogether excluded. Here he will see no angry conflict of passions, none of that feeling of bitterness and animosity, which never fails to attend the contests between man and man, between different classes in the same country, or between different nations: all proceeding from the same cause, or nearly so—a struggle for power; in other words, a struggle for dominion over man, and through him over the material things of this world. But in such a contest, what is gained on one side must be lost on the other. Here, on the contrary, however much may be gained, there can be no loss to any one. This is no paradox; for here the object of the contest is to increase man's knowledge, and with it at once his power over the material things of this world. It is plain, therefore, that in the objects we have in view, all have an equal interest; that the contest we are engaged in is one of friendly rivalry, all competing in their efforts to promote that knowledge, that science, which has been given to us as the reward of industry, and by which the gifts of a bountiful Providence may be increased and improved, for the benefit of man, to an extent almost unlimited.

But, Gentlemen, there are perhaps many here who have not been present at other meetings of the Association, who know nothing of the objects actually accomplished by it, and who are not acquainted with the records of its proceedings annually published. The question, therefore, may be asked, Does this Association actually promote the advance of science, and if so, by what means?

For a complete, detailed and triumphant answer to such a question, I must refer to the printed Reports of the proceedings. It would be unpardonable on my part to take up your time in endeavouring to perform a task, no doubt imperfectly, which has been achieved in the most complete manner by the very able men who on former occasions have undertaken it. I shall therefore only mention, that original researches in various departments of science, and on a great scale, have been carried on by the Association, upon which large sums have been expended under the most skilful management, and with very important results. The sum so expended exceeds 8000*l.* Much also has been accomplished for science, by the resources of the State applied under the advice of the Association; and within a few days it has been officially announced that the sum required for an important astronomical object, the publication of the Observations of Lacaille and Lalande, has been granted by Government.

For the previons reduction of the observations we are indebted to the zeal, ability and public spirit of Mr. Baily and Mr. Henderson, two members of the Association, who gave their services gratuitously, and took upon themselves the laborious duty of superintending the work. The actual expense incurred, amounting to 1400*l.*, was defrayed out of the funds of the Association.

I am also happy to be enabled to announce, that with respect to another great undertaking you all have heard of, which has been carried on at the public expense, under the gratuitous superintendence of a distinguished philosopher*, a most favourable notice has been published by a foreign geometrician of eminence: that notice, or essay, perhaps I should call it, will appear translated in the next number of the Scientific Memoirs. I regret I have not been able to procure a copy of the original essay, and therefore cannot say anything more precise about it; still I cannot refrain from mentioning it as a subject of much interest in the scientific world. In addition to the researches carried on by the Association, much has been done to aid research. A very important series of papers has been written and published in the annual volumes, under the head of "Reports on Researches in Science." Each of these Reports is, in fact, a complete and accurate general view of the actual state of that science, or branch of science, to which it refers,

* Mr. Babbage.

briefly, but profoundly, touching upon every point of interest, so that the man about to undertake the task of endeavouring to advance any particular branch of science may at once, by referring to one of these Reports, know where to look for that information which is indispensable to success, namely, an exact knowledge of all that has been done by others.

These Reports are so numerous, and embrace so wide a field, that to give any analysis of them within reasonable limits, would be impossible; and to form an adequate estimate of their importance, it is absolutely necessary to examine them in detail, just as they have been published. However, it appears to me, that without presupposing any knowledge whatever of these matters, or of the past history of this Society—without assuming that it has in any one instance effected, by joint co-operation, important and laborious researches in the cause of science, still that, even to a person who will not take the trouble of inquiring and informing himself, an answer to the question, Does the Association advance science? may be returned, short but conclusive. The answer I should give would be this: I appeal to the experience of every man at all conversant with the history of science, and with the working of scientific societies, whether it is not an indisputable fact, proved by experience, that all such societies, when properly conducted, are powerfully instrumental in promoting the advance of science.

Unfortunately, it sometimes happens, that when a new society springs up, it in some degree interferes with a society previously existing. This Association, however, interferes with no other society, and therefore, setting aside the great objects actually accomplished, far beyond the pecuniary resources of other societies, and for which I take no credit, because I presume for a moment they are unknown, it appears to me, nevertheless, to follow irresistibly, that this Association, acting precisely as other learned societies do—using the same means, and exerting a similar indirect influence, must likewise, just as they are, and on a scale just proportioned to its magnitude, be eminently useful in urging on the advance of science.

It may, perhaps, be worth while to inquire for a moment in what way the associations of scientific men promote science. The inquiry, however, cannot alter the fact that they do so, for that fact is based on experience. There are many and very obvious ways in which they do so. I shall mention but one.

The love of truth; the pleasure which the mind feels in overcoming difficulties; the satisfaction in contributing to the general store of knowledge; the engrossing nature of a pursuit so exalted as that of diving into the wonders of the creation; all these are very powerful incentives to exertion; and under their influence great works have been undertaken in the cause of science, and carried through to a successful termination; but I believe few will be disposed to deny that further inducements must be highly useful.

Let it be for a moment recollected, that where any, even the most trifling, step in advance has been gained, except perhaps the accidental discovery of a simple fact, there has usually been a long and laborious course of previous preparation. It has been necessary, even in the more popular sciences, to know accurately, first, what had been done by others; to see distinctly the boundary line between the known and the unknown, before there was the least chance of effecting anything; and in the higher departments of science such is the time to be expended, so great the toil to be endured in ascending to that elevation, from which the difficulties to be encountered but just begin to appear, that the task is one to which the undivided energies of man exerted for many years are no more than commensurate.

But the necessary preparations accomplished, then the real difficulties commence. Some perhaps apparently new principle suggests itself; it is followed, with great expenditure of time and labour, to its remote consequences, and it turns out to be perfectly barren and worthless.

One disappointment succeeds another, and years of toil pass away and no result. Under these trying circumstances the associations of scientific men afford their friendly aid; they soothe disappointment, excite hope, and prepare the way for redoubled exertion; they call into active existence that principle which has been implanted in our nature for the noblest purposes—the legitimate ambition of meriting and receiving the approbation of our friends and associates. In the ordinary circle of acquaintances, the man engaged in scientific pursuits will find very few, if any, who can understand and appreciate his labours; but in such associations as this, there are always many who see exactly the object aimed at, the difficulties to be encountered, and who are ready to acknowledge with gratitude every successful effort in the cause of science.

It is thus, without having recourse to other considerations, that I account for the fact, that the associations of scientific men, even when they employ no large funds, and perform no gigantic labours, as this Society does, still, by their indirect action, accelerate very greatly the progress of scientific discovery.

But this Association performs other important services. It appears to me to diffuse over scientific inquiry (if I may so express myself) a salutary influence—a healthy vigour of action. What more calculated to dispel that feeling of languor and weariness, the consequence of excessive mental labour long continued, than the freshening excitement of an interchange of ideas with men to whom the same course of research had long been an object of interest? What more likely to extinguish any petty jealousy which might arise—and scientific men, like other men, have their weaknesses sometimes,—than to bring all the parties together in friendly intercourse, where they cannot but feel they have a common object, and are working in a common cause—the discovery of truth?

Again: should the mind, pursuing in retirement some single scientific object, raise up to itself notions exaggerated and unreal, of the importance of that object, and then, elated and misled by some trifling success, should it throw off the garb of humanity, the characteristic of science pursued in a proper spirit, what more calculated to dispel the illusion than these meetings, where the man, however eminent in that branch of science to which he may have devoted his almost exclusive attention, will be sure to find others immensely his superior in every other department of human knowledge? And it is not merely for the sake of individuals engaged in the pursuit of science that these consequences are so valuable; it is also for the sake of science itself.

It is important that science should stand before the world in an aspect which is not forbidding, and we may rest assured of this, that wherever there may be the least trace of petty jealousy, of prejudice, or of pride, the world will not be slow to discover it; and as science claims as one of its noblest attributes, the power of exalting and enlarging the mind, and of arming it against such weaknesses, it will thus be exposed to the charge of having preferred pretensions to which it has no just title.

I will not detain you by enlarging upon the other obvious beneficial consequences of these meetings, such as the opportunities they afford for the free discussion of questions upon which the concentrated knowledge of individuals may be brought to bear with so much success—the opportunities they afford for the formation of new friendships between scientific men, often fraught with consequences very important to science, and the necessary tendency of them to encourage a taste for science. Upon all these I will abstain from offering any observations. There is, however, one consequence of these meetings, to which, if you will permit me to detain you a moment longer, I will just advert.

It has been remarked by a modern traveller of considerable depth of observation, that he had always found in the children of the fields a more determined tendency to religion and piety than amongst the dwellers in towns and cities, and that he conceived the reason to be obvious—that the inhabitants of the country were less accustomed to the works of man's hands than to those of God. May not the observation be of more extensive application than at first sight appeared? and if it be true that where we dwell constantly in large cities the mind is liable to be led astray by the habitual contemplation of the works of man, forced upon it imperceptibly by the continual succession of ideas—all of the same character—all originating in objects which have been shaped and fashioned by man, may it not also be true that it is equally liable to be led astray where it concentrates its whole attention, and exerts its whole energy without relaxation in the contemplation of the greatest of all human works, that which the labour of so many centuries has raised up—the structure of the abstract sciences? And if that be so, what more calculated to unbend the mind, and to divert for a season the current of ideas into other channels, than these periodical meetings, where, in the proceedings of every section, matter will be found of the deepest interest to every true philosopher; and where, however dissimilar the facts, however varied the inferences, the result will everywhere be still the same—that of putting forward more prominently in bold relief the wonderful works of creation? It appears to me, if I may presume to offer an opinion on such a subject, that the continual progress of discovery is destined to answer objects far more important than the mere improvement of the temporal condition of man. Were there a limit to scientific discovery, and had we reached that limit, we should be in the condition of a man who, with the most splendid landscape before him, was insensible of its beauty because the charm of novelty had passed away. Each successive discovery, as it brings us nearer to first principles, opens out to our view a new and more splendid prospect, and the mind, led away by its charms, is carried beyond and far above the petty and ephemeral contests of life; but the more rapid the discoveries are, the more powerful the charm, and therefore great is the motive for exertion; and in labouring in this cause there is this gratifying reflection, that our labours cannot injure our successors, for the region of discovery is rich beyond the powers of conception; and however much we may draw from it we shall not leave its treasures exhausted—no, not even diminished, because they are infinite. This Association has already accomplished much; I feel persuaded it will accomplish much more; but of this we may rest assured, that however long it may endure, and I see no principle of endurance which other societies have that is here wanting, it will find an ample and an enlarging field of useful employment.

Report of the Council to the General Committee.

1. The Local Secretaries for the Cork Meeting having stated to the Council the expediency of appointing an additional resident Local Secretary to assist in the arrangements for that meeting, and having named William Clear, Esq. of Cork as a very desirable person to fill the office, the Council appointed Mr. Clear one of the Local Secretaries for the Cork Meeting.

2. The following Resolution, passed at a Meeting of the General Committee held at Manchester on the 29th of June 1842, was communicated to the Council by the General Secretaries, viz.—

> "That the President and Officers of the British Association, with the assistance of the Marquis of Northampton, the Dean of Ely, Sir John Herschel, and Francis Baily, Esq., be a Committee to make application to Government to undertake the publication of the Catalogue of Stars in the *Histoire Céleste* of Lalande and of Lacaille's Catalogue of the Stars in the Southern Hemisphere, which have been reduced and prepared for publication at the expense of the British Association; and that the President and Council of the Royal Society be requested to support the application. The Dean of Ely to be the Convener of this Committee."

A Report in conformity with this Resolution,—requesting the co-operation of the Royal Society in an application to Government to defray the expenses of the publication of these Catalogues,—having been prepared by the Committee appointed for that purpose, was approved by the Council; and the Dean of Ely, Chairman of the Committee, being also a Member of the Council of the Royal Society, was requested to present the same to the President and Council of the Royal Society in the name of the British Association.

The President and Council of the Royal Society having declined to accede to this request, the following application to Government from the British Association alone was approved by the Council and transmitted by the General Secretaries to Sir Robert Peel.

(Letter No. 1.)

"2 Duke Street, Adelphi, April 6, 1843.

"Sir,—We beg leave most respectfully, on behalf of the British Association for the Advancement of Science, to solicit the aid of Her Majesty's Government in the publication of the following works:—

"The first is the Catalogue of the Stars in the *Histoire Céleste* of Lalande exceeding 47,000 in number, which have been reduced under the superintendence of Mr. Francis Baily.

"The second is the Catalogue of Lacaille's Southern Stars, exceeding 10,000 in number, which have been reduced, catalogued, and prepared for the press under the superintendence of Professor Henderson, the Astronomer Royal of Scotland.

"The expenses already incurred in these reductions exceeding £1400, have been entirely defrayed from the funds of the British Association, at whose request they were undertaken. The further charge required for printing and publishing these Catalogues would not exceed £1000.

"The British Association at their last Meeting at Manchester considered their funds inadequate to meet this charge, being already pledged to a very large amount for the publication of the extended Catalogue of the Astronomical Society, and for various important scientific researches and experiments; and they consequently requested the General Secretaries, the Dean of Ely, Sir John F. W. Herschel, Bart., the Astronomer Royal, and Mr. Francis Baily, to apply to Her Majesty's Government for a grant of the requisite funds.

"In virtue of this commission we venture most respectfully to beg, 'that Her Majesty's Government may be pleased to place a sum not exceeding one thousand pounds at the disposal of Sir John F. W. Herschel, Bart., and Mr. Francis Baily, towards defraying the expenses of printing the copies of the reduced catalogues of Lalande and Lacaille, to be disposed of in such manner as the Commissioners of Her Majesty's Treasury may direct.'

"We beg to assure you, Sir, that we consider the speedy publication of these Catalogues as of great importance to the progress of Astronomy, as furnishing the best means of comparing the positions of the stars of the two hemispheres at distant intervals of time, and of thus ascertaining the minute changes which many of them have undergone.

"We have not ventured to intrude upon your valuable time by asking for the favour of a personal interview, but if you should consider any further explanation necessary, we shall be ready to wait upon you at any time you may appoint. "We have the honour to remain most respectfully,

"Your obedient Servants,

(Signed) "RODERICK I. MURCHISON, "EDWARD SABINE, } General Secretaries.
"GEORGE PEACOCK.
"J. F. W. HERSCHEL.
"G. B. AIRY.
"FRANCIS BAILY."

To the Right Honourable Sir Robert Peel, Bart., First Lord of Her Majesty's Treasury."

This application gave rise to the following correspondence, viz.—

(Letter No. 2.)

"Treasury Chambers, April 24, 1843.

"GENTLEMEN,—The Lords Commissioners of Her Majesty's Treasury have had under their consideration your letter of the 6th instant, in which you request that a sum, not exceeding one thousand pounds, may be advanced by Her Majesty's Government towards defraying the expense of printing the copies of the reduced Catalogues of Stars of Lalande and Lacaille, prepared under the superintendence of Mr. Francis Baily and Professor Henderson.

"Their Lordships have directed me to state, that they feel it unnecessary to assure you of their disposition to promote every object of importance to science which you may consider it essential to make a recommendation to this Board.

"Their Lordships, however, cannot but express their regret that they were not originally apprized of the intention of embarking in the work in question, or of the probability of the Government being called upon to defray so considerable a proportion of the expense.

"The inconvenience of being required to defray expenses of works already commenced, without any previous consideration or concurrence of My Lords, is very great; and I am therefore directed by their Lordships to request to be informed of the circumstances which have rendered the funds of the British Association incompetent to complete the work which has been commenced, and what are the other important scientific researches to which you refer in your said letter as having engaged the funds which would otherwise have been applied to this object.

"I am, Gentlemen,

"Your obedient Servant,

"C. E. TREVELYAN."

"*To the British Association for the Advancement of Science.*"

(Letter No. 3.)

"2 Duke Street, Adelphi, June 10, 1843.

"SIR,—As one of the General Secretaries of the British Association, I have the honour to reply to your letter of the 24th of April, addressed to that body, and to state very briefly the circumstances under which the Reductions of the Stars in the *Histoire Céleste* of Lalande and in the *Cœlum Australe Stelliferum* of Lacaille, were undertaken by the British Association.

"Grants of money for these works (as well as for a Catalogue of about 8500 stars, reduced up to the present time, to be called the British Association Catalogue) were voted upon the earnest recommendation of the Committee of the Mathematical and Physical Sciences in the year 1837, at a period when the funds of the Association were very considerable from the accumulation of the life subscriptions of its members, and when those funds had not been seriously reduced by grants for other scientific objects, which have since occurred, to the amount of nearly £12,000.

"The reductions of those stars, when once resolved upon, were prosecuted with great activity; and at the last meeting of the Association, held at Manchester, Sir John Herschel and Mr. Baily reported that all the three works were severally completed and ready for the press. The General Committee voted the requisite sum for the publication of the British Association Catalogue, as being a work of the most pressing importance for the purposes of practical astronomy; but their funds were found to be inadequate to the publication of the other two valuable catalogues, consistently with their engagements for grants for other objects, and for the completion of other undertakings which were in progress. Under such circumstances therefore it was considered expedient to make an application to Her Majesty's Government for the grant of the funds requisite for the completion of these works, which were considered so important for the interests of astronomy.

"The Committee were encouraged to hope that such an application would not be disregarded, from the prompt attention which was formerly paid to an application, made upon the recommendation of the same Committee for a grant of funds for the reduction of the Planetary and Lunar Observations made at Greenwich from the time of Bradley downwards; a vast and important undertaking, which is now nearly completed under the superintendence of the Astronomer Royal.

"I beg to forward to you the last volume of the Reports of the British Association, in which, at pages xxvi. to xxix. of the Introduction, will be found a statement of the sums actually paid for scientific objects and researches from the date of its first establishment, amounting in the whole to upwards of £8300. The existing available property of the Association now scarcely exceeds £5000, invested in the public funds, which is already pledged to the extent of £3339 5*s.* for grants made at the last Annual Meeting at Manchester, the particulars of which may be seen in pages xxv. and xxvi. of the accompanying volume; and this available property may be further reduced by other claims that may be made on it at the next Annual General Meeting.

"During the eight years that the Association has been in active operation, it has appropriated £2200 upon astronomical tables and reductions; £1550 upon the reduction and discussion of observations on the tides; £1400 upon meteorological and magnetical instruments, observations and reductions; £900 upon experiments for determining the best form of vessels, and for other researches connected with this inquiry; £400 upon experiments on the manufacture of iron and the strength of materials; and upwards of £5000 upon experiments and researches on medical, botanical, zoological and various other branches of science. And it is proper to add that the whole of these sums have been appropriated without any prospect or intention of remuneration to the Association; and that no part of this money is ever applied to defray the personal expenses, or to compensate for the loss of time and trouble of those members of the Association by whom these researches or experiments are undertaken, and who have all rendered their services gratuitously.

"The Committee trust that the preceding statement will be sufficient to satisfy the Lords Commissioners of Her Majesty's Treasury that the funds of the Association have been expended, and nearly exhausted, upon objects of the highest national and scientific importance, and that the present application to their Lordships for assistance has not been made on slight or inefficient grounds.

"I beg to add that, in making this application, the British Association have no intention or wish to derive any benefit or advantage from the printing of the two works in question. They desire to place the whole at the disposal of the Government, to be gratuitously distributed amongst scientific persons, in the same way as the Greenwich Observations are now disposed of, or in such other manner as the Government may direct; and their sole wish is that the two important works, on which so much expense and time and labour have been already expended, should not be eventually lost to the public through the want of some further support.

"I have the honour to be, &c.,

"*C. E. Trevelyan, Esq.*" "EDWARD SABINE."

(Letter No. 4.)

"Treasury Chambers, 1st August, 1843.

"GENTLEMEN.—The Lords Commissioners of Her Majesty's Treasury have had under their consideration your letter of the 10th June last, in which you request that a sum not exceeding £1000 may be advanced by Her Majesty's Government towards defraying the expense of printing the copies of the reduced Catalogue of Stars of Lalande and Lacaille, prepared under the superintendence of Mr. F. Baily and Professor Henderson; and I am directed by their Lordships to acquaint you that the necessary directions will be given for issuing £1000 for the completion of the works in question. I am at the same time to state, that the compliance with this application must not be considered as authorising the expectation of any pecuniary assistance in cases not in the first instance submitted to and approved by My Lords.

"I am, Gentlemen,

"Your obedient Servant,

"*To the British Association* (Signed) "C. E. TREVELYAN."
for the Advancement of Science,
2 Duke Street, Adelphi."

The Council congratulate the General Committee on the ready disposition which Her Majesty's Government has shown to receive favourably and to comply with this recommendation made by the British Association on the behalf of science.

3. The following Resolution of the General Committee at Manchester was communicated to the Council by the General Secretaries:—

> "That £200 be placed at the disposal of the Council for the purpose of upholding the establishment in the Kew Observatory. That all instruments, papers, and other property of the Association be placed in the Kew Observatory when not employed in carrying on scientific inquiries for the Association, and that the Secretaries be instructed to adopt the necessary measures for carrying this resolution into effect."

The Council have made the following arrangements for the care of the

Kew Observatory :—Mr. Cripps, who had charge of the Observatory under the department of Woods and Forests, remains in the apartments he previously occupied, but without receiving a salary, undertaking to keep the house aired and the lower part clean and in good order, the Association being at the expense of cleansing materials, and of an allowance of fuel and candles, not exceeding in value £15 per annum.

Mr. Galloway has been engaged at a salary of £27 7*s.* 6*d.* per annum, with apartments in the Observatory, fuel and light, to take charge of the rooms above the basement story, and of the property of the Association placed therein ; to render general assistance to Members of the Association who may be prosecuting researches at the Observatory ; and to obey to the best of his ability whatever instructions he may receive from time to time from the Members of the Council or other authorised persons.

The Council have ordered a few necessary repairs to be made, including arrangements for the apartments of Mr. Galloway, and for a spare sleeping room in case the prosecution of any scientific researches at the Observatory should render it desirable for any Member of the Association to pass a night there.

The necessary instruments were purchased, and a regular Meteorological Register was commenced by Mr. Galloway (under the superintendence of Professor Wheatstone) in November last.

For these various purposes the sum of £133 4*s.* 7*d.* has been expended in the present year out of the £200 placed at the disposal of the Council.

A Report will be presented to the Association by Professor Wheatstone, descriptive of the Self-registering Meteorological Apparatus, for which a special grant of £50 was made to him at Manchester, and which has been completed and placed in the Observatory.

At the close of the first year, therefore, the Council have to report the establishment of the following registries, viz.—

1. An ordinary meteorological record with standard instruments.
2. A meteorological record with self-registering instruments on a new construction.
3. A record of the electrical state of the atmosphere.

It is proposed to add to these a registry of the comparative amount of rain at different heights above the surface, and of the temperature at different depths beneath the surface, for both which purposes the locality appears particularly well-suited : statements of the methods proposed to be employed, and applications for the necessary grants will be brought forward in the course of the present meeting by Mr. Phillips and Professor Wheatstone.

The Council hope that the General Committee will be satisfied with the progress which has been made during the past year, towards placing the Kew Observatory in a state creditable to the Association, and advantageous to science ; and that, mindful of the circumstances under which the building was obtained, and of the various problems in experimental philosophy to whose solution it may be rendered subservient, they will regard favourably the desire of the Council to embrace every suitable occasion of augmenting and perpetuating its usefulness.

4. The Council have added the names of M. Bessel of Königsberg, M. Jacobi of Königsberg, Dr. Adolphe Erman of Berlin, M. Paul Frisiani, Astronomer at Milan, and Professor Braschman of Moscow, to the list of Corresponding Members of the British Association.

5. It has been notified to the Council that an invitation will be presented to the British Association in the course of the present meeting, to hold the Meeting in the year 1844 at York.

Report of the Committee, consisting of Professor Wheatstone, Mr. Hutton, *and the General Secretaries and Treasurer, appointed by the Council to superintend the establishment of Meteorological Observations at the Kew Observatory.*

The limited funds at the disposal of the Committee have not allowed them to carry many of the contemplated objects into effect. The preliminary arrangements have however been completed, and a very perfect and efficient apparatus for making observations on the electricity of the atmosphere has been established. The Committee has paid more immediate attention to this subject on account of its importance in connexion with the system of simultaneous magnetic and meteorological observations now making on various points of the earth's surface, in the recommendation of which the Association has taken so prominent a part. Hitherto electrical phænomena have been little attended to at these observatories, from the want of knowing what instruments to recommend for the purpose, and how to interpret properly their indications. This want the Committee has every reason to believe will shortly be supplied and arrangements be made for recording the electrical changes of the atmosphere at the various stations with the same regularity and accuracy as the other meteorological phænomena.

The following is a brief notice of the present arrangements.

The dome in which the Equatorial was formerly placed, has been converted into the Electrical Observatory. A circular pedestal about eight feet in height is firmly fixed in the middle of the room, and a platform, which is ascended by a few steps, surrounds the pedestal, so that the operator standing upon it shall be at a convenient height to adjust and observe the various instruments. At the centre of the pedestal is fixed a strong glass pillar supporting a vertical copper tube tapering upwards; the length of this conductor is twenty feet, sixteen feet being elevated above the dome in the open air. The lower part of the conductor within the dome carries four horizontal branches placed at right angles to each other; these are for the purpose of bringing into connexion with the conductor the various electrometrical instruments employed. The electricity of the atmosphere is collected by means of the flame of a lamp kept constantly alight during night and day, and placed at the upper extremity of the conductor; by this plan, which Volta recommended, much more electricity is collected than by means of a metallic point; the lamp is lowered and elevated when required by means of a cord and pulley contained within the tube.

The insulation of the conductor is preserved by the effective method proposed by Mr. Ronalds. The insulating glass support has in its interior a hollow conical space the base of which opens into the pedestal; beneath this opening is placed a small night-lamp, which heats the air within the cone and raises the temperature of the glass pillar. The upper part of the external surface of this pillar is not sufficiently heated to prevent the deposition of moisture, and is therefore, to a certain degree, a conductor; the lower part also conducts slightly on account of its elevated temperature; but there is a zone between these two parts which insulates perfectly on account of the temperature of that part of the surface being sufficient to expel all moisture and yet not sufficient to enable it to conduct. A conductor thus insulated will retain its charge for hours together without sensible diminution.

Another peculiarity and advantage of this method of insulation is, that the active parts of all the electrometers are suspended from the conductor, and are therefore uniformly charged, depending for their insulation on the warmed glass pillar only, and not, as usual, upon separate insulators which dissipate the electricity unequally.

The instruments which are at present in action are,—1st, two Volta's straw electrometers, one degree of the second corresponding with five degrees of the first; 2nd, a Henly's electrometer, one degree of the scale of which is equivalent to ten degrees of the least sensible of Volta's electrometers; 3rd, a modification of Coulomb's torsion electrometer, which, while it possesses the sensibility of the most delicate of Volta's straw electrometers, has a range as great as the preceding three instruments; 4th, a dry pile electrometer; 5th, a discharging electrometer for measuring the lengths of sparks; 6th, an atmospheric galvanometer with 2400 well-insulated coils, made by Gourjon of Paris; 7th, Mr. Ronalds's modification of Landriani's electrograph, an ingenious instrument which records, during the absence of an observer, the electrical states of the conductor, distinguishing the positive from the negative states, and to a certain degree the variations of intensity. Many other instruments are in progress from which new and useful results are expected, but which it would be at present premature to mention.

Since the apparatus has been completed the conductor has remained constantly charged, unless purposely discharged, or during the momentary transitions from one electrical state to the other. The electric tensions vary in serene weather between 3° and 90°, and the diurnal changes are indicated with great precision. This report is accompanied by a sectional drawing of the Electrical Observatory, and by a register of observations commenced on July 1st, and continued regularly for six weeks. Observations made during the same time with the barometer, pluviometer, thermometer, psychrometer, Daniell's and Saussure's hygrometers, &c., are also annexed to the report.

Report on the Electro-magnetic Meteorological Register. By Professor Wheatstone, *F.R.S.*

The electro-magnetic meteorological register which I undertook to construct for the Observatory of the British Association is just completed. I will defer to a future occasion a full account of its mechanism, and of the various modifications I have devised to render it suitable for the different purposes required in meteorological investigations; such an account will more properly accompany the record of the daily working of the instrument, which I hope to present at the next meeting of the Association. I will confine my present report to a concise description of the instrument in its present state, but before proceeding to this I will briefly mention what it effects.

It records the indications of the barometer, the thermometer and the psychrometer every half-hour during day and night, and prints the results, in duplicate, on a sheet of paper in figures. It requires no attention for a week, during which time it registers 1008 observations. Five minutes are sufficient to prepare the machine for another week's work; that is, to wind up the clock, to furnish the cylinder with fresh sheets of paper, and to recharge the small voltaic element. The range of each instrument is divided into 150 parts; that of the barometer comprises three inches, that of the thermometer includes all degrees of temperature between $-5°$ and $+95°$, and the psychrometer has an equal range.

The machine consists essentially of two distinct parts: the first is a regulator clock, to which are attached all the regularly recurring movements which require to be introduced; the second is a train having an independent maintaining power, which is brought into action at irregular periods of time by the contact of the plunging wires with the mercury of the instruments, as will be hereafter explained.

The principal regularly recurring actions connected with the clock train are two: by means of one the plungers are gradually and regularly raised in the tubes of the instruments during five minutes, and are allowed to descend during one minute; by means of the other, a small type wheel, having at its circumference fifteen figures, is caused to advance a step every two seconds, while another type wheel, having twelve spokes but only ten figures, is caused to advance one step when the former completes a revolution. The complete revolution of the second type wheel is effected in six minutes, that is, in the same time occupied by the ascent and descent of the plungers. Thus every successive division of the range of an instrument corresponds with a different number presented by the two type wheels, the same division always corresponding with the same number. The two blanks of the second type wheel are presented during the return of the plungers, which occupies a minute, and during which time no observation is recorded.

The breaking of the contact between the plunger and the mercurial column in an instrument obviously takes place at a different position of the type wheels, according as the mercury is at a different elevation; if, therefore, the types be caused to make an impression at this moment, the degree of elevation of the mercury will be recorded. It will be seen that observations in different half-hours are not made at exactly corresponding instants; but this is of no consequence, as the instruments will not sensibly vary within five minutes, the greatest possible extent of the deviation.

I will now proceed to describe the means I employ for recording the number corresponding to the degree of elevation of the mercury. To simplify the explanation, I will at first suppose the indications of a single instrument only are to be registered. One end of a conducting wire is connected with the mercury in the tube of the instrument, and the other end with the brass frame of the clock, which is in metallic communication with the plunger. In the course of this circuit an electro-magnet, such as I employ in my electro-magnetic telegraph, and a single very small voltaic element are interposed. The electro-magnet is so placed as to act upon a small armature of soft iron connected with the detent of the second movement. All the time that the plunger is in the mercury the armature remains attracted, but at the moment the plunger leaves the mercury the attraction ceases, and the release of the detent causes a hammer to strike the types and impress them by means of black copying paper on the cylinder. The armature subsequently remains unattracted until the plunger descends; immediately before it reascends, a piece of mechanism, connected with the clock movement, brings the armature into contact with the magnet, which remains there, in consequence of the recompletion of the circuit, until the contact is again broken.

It might be thought that a separate striking movement and a separate pair of type wheels would be required for each different instrument; but a very simple contrivance enables me to register the indications of all the instruments, employing for each by means of the same apparatus. For this purpose a rheotome is so placed in the voltaic circuit as to divert the current each successive six minutes, so that the circuit shall be completed by a different instrument. Thus, the barometer is registered during the first six minutes of the half-hour, the thermometer during the second six minutes, and the psychrometer during the third six minutes. Two six-minute spaces are left for any other two instruments which it may be hereafter desirable to add. It is not necessary that the completion of the circuit should be effected by mercury, and there are very few meteorological instruments which cannot be applied by suitable modifications to this register.

It may be necessary to mention another important point in the construction of the machine. As the first type wheel shifts every two seconds, and as the plunger may leave the mercury at any instant of time, the hammer might strike during the shifting of the type wheel and produce a blurred or imperfect impression; to obviate this a contrivance is introduced, for the purpose of continuing the current for an instant after the plunger leaves the mercury, whenever the contact is broken at the moment the type wheel shifts. By means of this addition all the observations are registered with regularity and distinctness.

The accuracy of the recorded observations is not in the slightest degree influenced by the rate of going of the clock. Whether the rate be accelerated or retarded, the same number is always printed for the same degree of elevation of the mercury. The only circumstance affected by the variation of the time of the clock is the time of the observation.

The elevation of the mercury in the tube by the insertion of the plunger gives rise to no error, because the observation is recorded only at the moment the plunger leaves the mercury, and when the mercury is consequently at its proper level.

A description will also be presented to the Association by Professor Wheatstone of an Electrical Apparatus which has been established in the cupola of the Observatory; the cost of this apparatus has been defrayed by private subscription.

REPORTS

ON

THE STATE OF SCIENCE.

Third Report upon the Action of Air and Water, whether fresh or salt, clear or foul, and of various Temperatures, upon Cast Iron, Wrought Iron, and Steel. By Robert Mallet, *Mem. Inst. C.E., M.R.I.A.*

283. The first Report upon these subjects which I had the honour of presenting contained a statement of the condition of our knowledge therein up to that time, and cleared the way by the removal of certain errors as to the supposed methods of protecting iron from corrosion: it also indicated the principal directions in which further information was requisite in six *desiderata* which demanded experimental answers.

The second Report supplies information as to three of these, and less completely as to the remaining three; and as in course of inquiry some other correlative branches of investigation suggested themselves, so it also enters pretty fully into the question of the protection of iron from corrosion under various conditions by the application of zinc in different forms; of the causes of variation of specific gravity, and its effects upon the corrodibility of cast iron; of the comparative durability and best constitution of paints or varnishes for the preservation of exposed iron, upon which several experiments are given; and also gives the first set of tabulated results as to the corrosive action of air and water upon cast iron under the five several conditions of experiment. One of the most important objects of those tabulated results was to determine the actual loss of metal by corrosion in a given time and in given conditions of most of the principal *makes* of cast iron in Great Britain, and hence to find their relative durabilities when used in construction, and by subsequent discussion of the results obtained to discover, if possible, upon what durability depended, whether upon the nature of the constituents of the compound alloy known as cast iron, or upon their proportions, or upon either of these in connection with the state of aggregation of the mass.

The first period of exposure of about eighty-two different sorts of iron (chiefly cast iron) occupied 387 days, and from this alone the above conclusions might have been sought; but it became obvious, in course of inquiry, that the original state of the metallic surface when first exposed had much to do with its rate of corrosion, and that this became subsequently modified as it proceeded, and thus that the amount of loss of metal by corrosion might not follow a law of equidifference, but might increase or decrease in rate upon continued exposure. To arrive, therefore, at greater certainty in assigning for the practical engineer the actual loss of metal after long periods of exposure, and to obtain the amount of this increment or decrement, the whole of the specimens previously exposed were, after examination and weighing, again immersed in their respective classes of sea or fresh water, and now, after a second period of exposure of 732 days, have been again taken up, examined, and weighed.

284. Since the publication of the second Report these inquiries have also been extended to wrought iron and steel, of which between twenty and thirty varieties have been submitted to experiment. These have been immersed under conditions similar to the cast iron, viz.—

1. In clear sea water, temp. 46° to 58° Fahr.
2. In foul sea water, temp. same.
3. In clear river water, temp. 32° to 68° Fahr.
4. In foul river water, temp. 36° to 61° Fahr.

and for the same period of 732 days. The results are given in the accompanying tables, so that we have determinations from two successive immersions of cast irons, and from one of wrought iron and steel.

285. In addition, tabulated results will be found of experiments continued under similar conditions, and for an equally long period, upon wrought iron coated with zinc by the ordinary zinking process, or "galvanizing" as it is called, and upon cast iron protected by the paint of powdered zinc (2nd Rep. 195).

286. Besides the preceding, the results are given of an entirely separate set of experiments on cast iron, wrought iron and steel, exposed freely to the weather, and to all the atmospheric influences at an altitude of about fifty feet above the surface in the city of Dublin. It may be presumed that the accurate measures, thus for the first time obtained, of the actual metallic loss by rusting of a great variety of irons in the atmosphere, will not be looked upon as valueless by the engineer; and accompanied as they are by the meteorological registers kept at the Royal College of Surgeons, Dublin, for the time of experiment, will enable analogous results to be deduced for other localities where meteorological registers are also kept sufficiently comparable for all practical purposes; indeed the climate of Dublin may be viewed as a tolerably fair average of that of the British Islands.

By a singular chance it happens that in the year 1840 (part of our period of experiment) the relative quantities of rain falling in Dublin and London are more than usually regular. There are on the average of six years—

	Days of no rain.	Fair.	No rain and fair.
In Dublin	150	56	206
In London	220	10	230

And the average quantities of annual rain are—

In Dublin 25·874 inches.
In London 21·714 inches.

July and August, which are *warm* months, are also generally *wet* months in Ireland. The actual quantities of rain which fell in Dublin and London in the two years of experiments were—

	1840.	1841.
In Dublin	25·788	28·882
In London	18·184	27·372

The temperatures were—

	1840. Daily Mean.	1840. Max.	1840. Min.	1841. Daily Mean.	1841. Max.	1841. Min.
In Dublin	50·34	85·0	26·0	50·15	78·0	19·0
In London	49·80	83·0	21·2	50·4	87·0	14·9

The barometric pressures—

In Dublin	30·349	Annual mean pressures*
In London	29·880	

All other circumstances being the same, the rate of corrosion of iron exposed to the ordinary atmospheric influences may be expected to vary in increase or decrease thus:—

1st. Directly as the volume of rain and dew falling on it in a given time, these fluids being supposed to contain similar amounts of combined air and free oxygen.

2nd. Directly as the elevation of temperature with equal moisture.

3rd. Directly as the barometer pressure.

The two last do not vary enough in our climate to produce very marked results, and probably the volume of rain and dew in a given time will be a tolerably exact measure of corrosion in any part of Great Britain.

The rate of corrosion will be rather greater in a crowded city (*cæteris paribus*), and greater over the sea than in the open country, the latter, owing to the presence of saline particles frequently in the air.

The series of tables is therefore now complete, and I would venture to hope, present to the engineer sufficient data to enable him to predict the term of durability and allow for the loss by corrosion of iron in all conditions when entering into his structures.

Their completion has involved no slight labour, having required more than five thousand accurate weighings to be made, without reference to other experiments.

287. In all the tables which follow and relate to the *second* period of immersion of cast iron and the standard wrought iron bar, viz. Tables I., III., V., and VII., the dimensions and weight of each specimen are given previous to immersion, its weight after the second exposure to corrosion, and the loss of metal for a unit of surface; and by comparing this in every case with the results given in column 10 of tables of second Report, having regard to the difference in absolute time of exposure in the first and second periods, the results given in columns 8 and 9 of this Report have been found, viz. the amounts of increment or decrement of corrosion of the same surface of the same iron when exposed at the first and second periods. Of course this information does not apply to the tables of wrought iron immersed for the first time only. The other information conveyed will be sufficiently obvious from the headings of the columns. The amount of corrosion of all the wrought iron and steel have been referred to the standard bar *a* 58, so that the whole suite of tables are comparable. The characters of corrosion of these have also been given as minutely as brevity permitted, and in a few set words throughout.

Discussing the results given in these tables, we are enabled to draw the following conclusions as regards, first,

Cast Iron.

288. The rate of corrosion is a decreasing one, at least where the coat of plumbago and rust first formed *has been removed* prior to second immersion, which was unavoidable in these experiments; but, as I shall hereafter show, where this coating remains untouched, the rate of corrosion remains much more nearly uniform, and is nearly proportionate to the time of reaction in given conditions. In some cases, however, even with this coating removed, an increment in the rate of corrosion has taken place; and it is observable

* It is uncertain that the pressures given are strictly the "Annual means," the Dublin Registers are incompletely reduced.

that this almost uniformly occurs in those specimens which had the smallest amount of corrosion at their first immersion. Thus there is a tendency to a greater equality in the index of corrosion in all the varieties of iron evidenced by the second than by the first immersion.

289. In the first period of immersion the amount of corrosion of all the thin cast specimens, those of 0·25 inch in thickness, was much greater than that of the thick or 1-inch specimens of the same iron in the same conditions, as remarked (2nd Rep. 178, 179), where this was shown to arise from a less homogeneity of surface in the thin than in the thicker castings.

The difference in their respective rates of corrosion is however much less on the second period of immersion, which arises from the fact that the removal of metal by the corrosion of the previous immersion had bestowed a much more uniform or homogeneous surface upon all the specimens.

290. The conclusions previously given therefore (2nd Rep. 175—187), as to the connexion between the size, form, method of casting, with consequent surface and amount of corrosion, are not only borne out, but we shall see reason to conclude that homogeneity of surface and texture, or the contrary, are by far the most important circumstances which vary the amount of corrosion in cast iron by air and water; that the rapidity of this is not so much dependent upon the chemical constitution of the metal as it occurs in commerce, as it is upon its state of molecular arrangement and the condition of its constituent carbon.

291. Upon collating the tables of the first and second immersions, it will be found that the specimens of cast iron, whose analyses are subjoined, are those presenting the maxima and minima corrosion.

It was to be presumed, that if the extremes of corrosion were connected with the constitution of the metal, a careful analysis would elicit that upon which the best qualities depended.

292. TABLE A.—ANALYSES OF CAST IRONS.

Of Maximum and Minimum Corrosion.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Constituents.	α 8. Doulais, No. 4. Hot.	α 12. Varteg, No. 2. Hot.	α 15. Arigna, No. 1. Cold.	α 24. Cinderford, No. 1. Cold.	α 25. Burchill's, No. 1. Cold.	α 38. Sunmerlie, No. 2. Hot.	α 41. Monkland, No. 3. Hot.	α 47. Muirkirk, No. 3. Hot.	α 56. Muirkirk, No. 2. Cold.	α 70. Carron, No. 2. Cold.	α 67 Harde[illegible] mixe[illegible]
Suspended graphite	1·22	1·92	3·21	2·23	2·74	2·96	2·81	3·11	4·28	3·10	0·[illegible]
Combined carbon	2·13	0·54	0·38	0·80	0·11	0·34	0·21	0·96	0·27	0·35	4·[illegible]
Phosphorus	0·21	0·18	...	traces.	0·13	traces.	traces.	traces.	traces.	traces.	trac[illegible]
Manganese	0·17	traces.	1·12	traces.	0·41	1·92	2·32	1·52	1·84	0·60	0·[illegible]
Alumina	...	...	...	...	...	0·07	0·10	0·04	0·03	0·54	..
Sulphur	...	...	traces.	...	...	traces.	traces.	traces.	...	...	..
Silica	1·21	3·41	0·04	1·97	2·00	0·94	1·34	0·89	0·70	1·12	3·[illegible]
Iron	95·06	93·95	95·25	95·00	94·61	93·77	93·22	93·48	92·83	94·29	92·[illegible]
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·[illegible]

On inspecting these results, however, in connexion with the tables, it will be evident that corrodibility does not depend upon the proportion of constituent carbon, and still less upon that of the other foreign matters usually found in cast iron, but upon the state in which the carbon exists in the compound, upon the state of aggregation of the whole mass, and upon the voltaic uniformity or otherwise of the surfaces exposed to corrosion. This is practically manifest from the fact before adverted to (2nd Rep. 179), that the very same sort of iron corrodes much faster when cooled irregularly and fast than it does when the contrary has been the case. Of this we have instances in the irons α 8 and 9, α 14 and 15, &c., of which analyses are given. Minute variations in the foreign alloying metals usually found in cast iron do not appear to effect its corrodibility, and the slight and uncertain difference which exists between hot and cold blast iron as to corrosion arises rather from their difference in specific gravity than anything else.

It is observable also that the important improvement of the hot blast has in this respect little deteriorated the quality of cast iron, as our experiments (α 26, 27) show that iron made thirty-five years ago in Scotland before its introduction differs very slightly in corrodibility from that of recent manufacture by hot blast.

293. It will be remembered that carbon exists in cast iron in two very different states, viz. as diffused graphite in a crystalline form and as combined carbon; that the dark gray and softer irons contain more of the former, the brighter and harder irons more of the latter. Now the latter kind have the property of being much less uniform or homogeneous of surface when cast under similar conditions than the former, while the highly graphitic irons, though more uniform in large specimens, are the least dense and softest in texture: hence the ultimate choice at which we arrive is, that the bright gray irons of high commercial marks, the No. 1 and 2, while they are in all other respects the most valuable for construction, are also the most durable.

294. Voltaic uniformity of surface is best attained by slow cooling of the metal when cast, and in all small castings will be much promoted by subsequent annealing out of contact of air, as in the process ordinarily used for decarbonizing cast iron to render it flexible and tough.

295. As the analysis of cast iron is admittedly a matter of some difficulty, to ensure trustworthy results, it may be proper to state briefly the methods pursued with those above given and with some others which it was needless here to bring forward.

One of the principal difficulties exists in the determination of the carbon; for this a number of methods have been proposed. Berzelius burnt the carbon by passing a slow current of dry oxygen over the pulverized metal, absorbing the carbonic acid by barytic water. He also proposed a similar process with dry chlorine, volatilizing the chloride of iron formed; and the methods by chloride of silver or copper.

Berthier devised a process by dissolving the metal in iodine or bromine, the object held in view by all being to avoid the loss of carbon which inevitably results from solution of the metal in acids evolving hydrogen. All these modes however are so tedious and beset with practical difficulties as to give uncertain results.

The method adopted by me in most cases was a modification of Regnault's process, which consisted in mixing the cast iron finely pulverized with about twelve times its weight of chromate of lead properly prepared and mixed with a little chlorate of potass. This is burnt in an ordinary combustion-tube, in the remote extremity of which some dry powdered chlorate of potass is placed, and heated after the combustion has been completed, so as to pass a current of oxygen over the ignited mass. This precaution is indispensable with the harder and denser irons containing most of their carbon in combination. The total amount of constituent carbon is thus obtained and weighed as carbonic acid; but this consists of graphite and of combined carbon. By a separate assay the graphite is obtained by solution of a weighed portion of the metal in nitric acid, as residue consisting of graphite, extractive matter (from the carbon of combination) and silica, and occasionally some oxides of combined metals. The residue is filtered and washed, boiled in caustic potass, by which the silex and extractive matter are taken up; the graphite remains: it is again washed with dilute muriatic acid, then with water, and weighed after drying. The difference between this and the total amount of carbon given by the combustion is equal to the carbon of combination.

For the other constituents, after a preliminary qualitative trial, about 120 grains of the cast iron were dissolved in nitric acid, evaporated to dryness with a strong heat, and ignited in a platina crucible with three and a half times its weight of carbonate of soda. After cooling, water is poured over it, which carries off the excess of alkali and an alkaline phosphate (or sulphate, if the iron contained sulphur, which should be ascertained beforehand), leaving the peroxide of iron to be separated by filtration.

The filtered liquor must now be boiled for some time to destroy the manganesiate of potass in solution and precipitate the manganese, again filtered, nitric acid added evaporated to dryness, and silicic acid separated, if any exist, on heating with water, after moistening with acid in the usual way.

Ammonia is now cautiously added, and if the iron contained aluminum, a basic phosphate of alumina precipitates, the solution, again filtered, is acidulated with acetic acid, and the phosphoric acid precipitated by acetate of lead. From the phosphate the phosphoric acid cannot be estimated with certainty, it was therefore converted into sulphate of lead, and the phosphoric acid got from its weight.

The silex and manganese were always obtained by precipitation from the iron, &c. in separate assays. The method with benzoate or succinate of ammonia, though inconvenient, is one of the best, where the amount of iron is considerable. Liebig's process of separation by boiling with carbonate of barytes succeeds very well and presents no difficulties, but where the amount of manganese is so very small in proportion to the iron I preferred the former mode. The iron itself, from its inconvenient bulk, was generally estimated from the other constituents.

Separate assays are also best made for sulphur or earthy bases, but as far as my observation goes, these are extremely rare in British cast iron of commerce.

296. The usual constituents are carbon, manganese, silicon and phosphoric acid, and the metal seems to be an *indefinite* mixture of carburet, silicuret, and phosphuret of iron and manganese, in all cases of gray iron, while the perfectly silver-white crystalline cast iron, which contains as much as 5·4 per cent. of carbon, does seem to be a *definite* quadri-carburet. This, however, is of little constructive value.

The observation therefore which has been made, that perfectly definite combinations are those least liable to change, and thus that definite metallic alloys are those least subject to oxidation, though true, is of no value to us here, as no commercial cast iron can be viewed in any other light but that of a chance mixture of constituents.

297. The view already given (1st Rep. 55) of the causes of tubercular or local corrosion with concretions of rust, namely, that it is due entirely to want of homogeneity of surface, is confirmed by the results of the second immersion. The surface of all the specimens was necessarily rendered more uniform by their first immersion, and accordingly we find much less tubercular corrosion has taken place on the same specimens in the same water during the second than it did during the previous exposure to corrosion. That alkalinity of the surrounding fluid is an apparent cause there is no doubt, but it seems to act only as an agent in increasing the action of partial voltaic currents on

a non-homogeneous surface, and aiding thus in the transfer of the oxides formed and not dissolved.

298. On opening the several boxes of cast and wrought iron after immersion, the special appearances of each specimen were as before marked, and the form of corrosion is stated in the respective tables. The phænomena generally were much the same as in the prior exposure, with the exceptions already adverted to. All the cast iron pieces in sea water were irregularly covered with a thin coat of carbonate of lime.

299. It may be observed, that the decrement of the rate of corrosion of all the cast iron specimens is considerable in the second immersion. For the purpose of obtaining the amount of corrosion in the first immersion, the coat of plumbago and rust formed was necessarily removed, and this, contrary to what might have been presumed, I am now enabled to prove is the chief cause of the decrement.

300. Six equal parallelopipeds of the same bright gray cast iron with planed surfaces were immersed in separate vessels in sea water, slightly acidulated with muriatic acid, and frequently renewed. Each of the six was removed at successive intervals of thirty days; the coat of plumbago and rust removed from the piece, which was dried and weighed. The following table gives the results.

The weight of the original pieces was in every case = 1060 grains. The temperature of the menstruum 54° to 67° Fahr.

TABLE B.

No. of Specimen.	No. of days' exposure to Corrosion.	Original Weight of each Specimen before exposure.	Weight of each Specimen after exposure for the above times.	Absolute losses of Weight by Corrosion.	Losses of Weight divided by the times of exposure.
		Grains.			
1	30	1060	1057·2	2·8	2·8
2	60	1060	1054·6	5·4	2·7
3	90	1060	1051·2	8·8	2·9
4	120	1060	1048·1	11·9	3·0
5	150	1069	1045·9	14·1	2·8
6	180	1060	1041·4	18·6	3·1

301. The specimens were all cast from the same mass, chosen with special regard to the uniformity of its texture; and the results of the preceding table show, that when the coat of plumbago and rust formed remains untouched during the whole period of immersion, the amount of this, or the actual loss of metal, is very nearly in proportion to the time of reaction, showing that the coating of plumbago and peroxide is negative with respect to the metal and aids in its corrosion. This result however applies much more to corrosion in salt than in fresh water, wherein the coat of rust formed is much harder and less porous; and hence, although still negative to the metal, partially defends it mechanically from corrosion.

302. It may be noticed, that on taking up the kyanized oak-boxes of specimens from Kingstown Harbour, after two years' exposure, the timber was found perforated nearly through a thickness of two inches by the *Limnoria terebrans*, whose ravages are thus proved not to be arrested by kyanizing.

303. I now proceed to some notice of the series of experiments in Table IX., on iron exposed to the atmosphere, &c. at Dublin. The forms in which cast iron corrodes in water of various sorts have been heretofore minutely

described; the action of moist air, however, produces both upon cast and wrought iron totally different forms of corrosion. Plumbago is not formed at all; rusting takes place with almost complete uniformity over the whole surface, and coat after coat of adherent rust is removed; at first each coat leaves a surface parallel to that of the original metal, but the whole surface gradually becomes fretted with minute concavities or indentations, at first scarcely visible, but gradually enlarging by several falling into one, until, after a lengthened period, the surface, originally flat or plane, is found covered with nearly hemispherical indentations often a quarter of an inch in diameter. This takes place whether atmospheric moisture lodges on the surface or not, and on both cast and wrought iron; its cause seems difficult of explanation.

304. The eudiometrical properties of water, by which, whether in the state of snow-water, as observed by Boussingault, or of rain, it contains a portion of free oxygen, render it, as before observed, a powerful agent in promoting oxidation.

Fresh-fallen rain after a time of drought, especially in cities, comes down so loaded with free oxygen, carbonic acid and ammoniacal salts, that it produces instantly a coat of *red rust* upon any iron placed in contact with it. Pure water, however large a portion of common air alone it contains, does not seem capable of producing any immediate oxide higher than the magnetic $FeO + Fe_2O_3$. The contrary is the case if carbonic acid or a minute quantity of any saline substance be in solution.

305. But the deposition of dew under certain circumstances originates the most immediate and powerful oxidation, as the following observation testifies.

On the 14th March, 1842, the temperature at Dublin, at 12 o'clock at noon, was high, and the day fine, but the air was nearly saturated with moisture, and dew rapidly collected on the polished parts of a large steam-engine which stood unfinished in a shady open building, whose temperature was considerably below that of the open air. In two hours time after, being wiped clean with cotton waste, all its bright work had a moist coating of red rust upon it. The rusty moisture could be swept off with the finger.

Whether electrical disturbance of the atmosphere is concerned in this, or whether occasionally the atmospheric moisture is loaded with saline matter, especially near the sea, I am unable to say; but the fact of such rapid action of deposited dew is remarkable, and is not confined to a single instance, having been noticed also to me by engineers as occurring frequently at Liverpool.

306. No second immersion of the cast iron series γ was practicable, the arrangements of the Dublin and Kingstown Railway Company, which enabled the first to be made, having been unfortunately discontinued.

307. Table XIV. shows the *average* results of the corrosion of all the cast irons in water on the second immersion, and those of the corrosion of cast iron in air (ζ). The numbers indicate that in general, in moist air, chilled cast iron corrodes much more *slowly* than that cast in green sand; the contrary being, as before stated, the result in water.

That the average loss on all varieties of cast iron in moist air is not much below that which takes place in clear sea water in an equal time, and is much above that produced by clear fresh water in the same period.

In the case of cast iron with the skin removed by planing, the loss in moist air is almost precisely the same as in clear sea water.

These facts show that the preservation of structures in iron exposed merely to the weather is much more important than has been hitherto presumed, and that without paint or some other more efficient covering, they perish almost as fast as if in the open sea.

308. We now proceed to some remarks upon the series of experiments upon

Wrought Iron and Steel.

The loss of metal by corrosion is, in every sort of water tried, much more rapid in wrought iron than in cast iron, and the same is the case with steel. It takes place however much less locally than in cast iron. The particular phænomena presented by the corroded wrought iron and steel are given in Tables II., IV., VI., VIII. and X. respectively. In almost every case the fibre or crystalline texture of the iron becomes developed by the removal of the alternating portions of metal. This dissection commences usually at the exposed ends of the fibrous crystals, is most rapid in the direction of the principal axes of the crystals, and sometimes extends to a great depth.

309. We thus learn that all wrought iron and steel consists of two or more different chemical compounds coherent and interlaced, one of which is electro-negative to the other, the electro-positive body being that which suffers first from corrosion. The electro-negative portions of the iron or steel remain bright and hold a perfect metallic lustre until the whole of the other portions are removed, or at least are so to a great depth, when they begin likewise themselves to oxidate. Most of the specimens, when first taken up, were found in this state, but soon tarnished on exposure to air. The great depth to which this removal of alternate layers takes place, is most remarkable in the case of Damascus iron (α 12) as it is called, made for the manufacture of fowling-piece barrels, and purposely formed of irons of two or more different qualities, faggoted together: here specimens of about half an inch thick, chosen with straight parallel fibres of alternate kinds, had the electro-positive strata (in β 26) removed quite through, so as to leave a grating of minute parallel rays that could be looked through.

310. In general, the finer the quality of wrought iron and the more perfectly uniform its texture, the slower and the more uniform is its corrosion in water, as we before found in the case of cast iron; minute difference in chemical constitution has very little effect on the rate of corrosion; thus the difference is slight between the index of corrosion of—α' 1, Gloucestershire iron of fine quality, tough, both hot and cold; α' 2, Staffordshire iron, red-short, containing sulphur and perhaps a trace of arsenic; and α' 3, cold-short Staffordshire iron, containing phosphorus in large proportion; but it is very great between these and α' 4, a common bar of inferior Shropshire iron. This iron, on examination of its fracture with a lens, showed the presence of innumerable microscopic spots of silicate of oxide of iron and of magnetic oxide. These immediately, on exposure to air and water, become partially converted into peroxide of iron, and being electro-negative to the iron itself, powerfully promote its corrosion. Hence such "slaggy" iron, as it is technically called, is to be avoided where durability is important.

311. To the general fact of uniformity of texture giving a small index of corrosion, unfinished bars from the puddling furnace, before the second rolling, are an exception. These bars contain a large amount of silex, and are extremely hard. They are of no constructive value, of course, but the experiments with them (α 10, 11, &c.) show that, as in cast iron, so here hardness or softness are elements in the rate of corrosion; and this is further confirmed by the results relating to steel, wherein the small amount of corrosion for hardened cast steel is remarkable.

The highly siliceous irons, however, corrode very locally, and appear to be partially defended from the reaction of air and water by a thin coat of silex formed upon them.

312. Of all the wrought irons experimented on, that which was found most durable under all possible conditions of exposure was faggoted scrap iron bar (α 14), that which had been most wrought, and which was not only most

uniform in texture, but proved, on subsequent chemical examination, to be most free from any foreign matter, consisting in fact of nothing besides iron, except a mere trace of carbon and silex. My former presumption (64) in favour of rolled bars is therefore partly erroneous.

Next to this in durability stands Low Moor Boiler Plate, an iron whose purity and excellence is universally known. These results make it plain that for iron ship-building the two latter kinds of iron are greatly to be preferred, and whether in clear or foul sea water, or in fresh or exposed to wet and dry, are very superior to common Staffordshire plates for this purpose.

The iron of which the faggoted bar (α 14) was formed, was best Staffordshire rivet iron of excellent quality. Comparing the results of the corrosion of the Dannemora Swedish iron with this, it is apparent that no superior durability is imparted by the Swedish method of refining over that obtained by our own puddling process, when properly conducted.

313. In Table XIV. the *average* results for all the wrought irons of most practical importance are given in each condition of experiment; those for the remaining sorts may be easily calculated from the previous tables.

314. Foul water, *i. e.* that evolving sulphuretted hydrogen, and other gases resulting from putrifying organic matter, acts, whether salt or fresh, much more powerfully upon wrought iron than when free from such impurities. The actual contact of soft putrid mud beneath salt water appears to be more destructive than the water itself.

315. In the autumn of the year 1832, I observed that small gas bubbles were constantly evolved from the mud at the bottom of some of the lagunes at Venice, which on reaching the surface became instantly luminous, and disappeared with, as far as could be judged, a real combustion.

The gas when collected, however, was not spontaneously combustible, and I had no means of examining it with precision.

It seems probable, however, that when large quantities of animal matter are in a state of decomposition, phosphorus in some of its combinations will always be found; and when iron is exposed under such conditions, a phosphate of iron is produced. This has actually been observed in the case of a large quantity of iron weapons discovered a year or two ago in a bog near Dunshaughlin, county Meath, along with a mass of bones of oxen, horses and other animals. The surface of most of the iron, which, after the lapse of some centuries, during which it was enveloped in damp peat, was in singularly good preservation, was almost uniformly covered with a bluish coat of phosphate of iron, quite similar apparently to the native blue phosphate.

316. Proceeding now to the experiments made

On Steel,

the results of which are given in the same tables with the wrought iron, we find that in general steel corrodes much more uniformly and a good deal more slowly than wrought iron.

That hardened cast steel, after "tilting," has the average minimum corrosion, and that low shear steel, which is in fact a sort of steely iron, has the maximum.

317. It was stated before (1st Rep. 21) that plumbago occasionally had been found from the action of air and water on wrought iron, as well as on cast iron. The present results show that raw or untilted cast steel always produces a brilliant shining plumbago like that from white cast iron, and in general that the production of plumbago by aqueous corrosion is dependent (so far as the metal is concerned), either in cast or wrought iron, upon the amount of combined carbon, and upon the state of aggregation of the particles of the

metal. The crystallized state appears to be essential to its production in the cases of wrought iron and steel. The pieces of raw cast steel experimented on were found converted into plumbago for about $\frac{1}{20}$th of an inch in depth, and on removing this, the surface of the metal was found covered with a beautiful interlacing of crystals.

318. Several experiments have been made to endeavour to arrive at a more perfect knowledge of the nature and formation of this peculiar substance, as yet, I regret to say, without much success, owing to the circumstance that the *same substance* cannot be produced at will, or in a moderate time by the action of acids on iron, and that great difficulty has been found in obtaining specimens both of the substance, and of the iron from which it resulted, in a fit state for experiment, viz. not acted on by air. I have however been favoured by Major-General Pasley, R.E., with some specimens from the Royal George, sent to me in hermetically sealed vessels, which promise to give the desired information as to what passes when this curious substance heats spontaneously in air, and how it is formed.

Attempts have also been made to collect and examine the peculiar organic bodies produced along with this by the action of acids, &c. on iron and steel. These substances are of great chemical interest by adding to the small number of organic bodies known to be formed directly. They are of the families of hydrocarbons and extractive matters, produced by the action of the evolved hydrogen upon the nascent carbon of the iron. They are produced, however, in very minute quantity in relation to the volume of hydrogen, and hence it has been necessary to operate on immense volumes of the gas evolved from iron, &c. to collect these new bodies in sufficient quantity for examination; owing to this, to their entanglement with the sulphur, phosphorus, &c. of the iron, and to the powerful affinity of some of them for oxygen, they have as yet not been collected in mass sufficient for accurate examination. Two hydrocarbons have however been distinguished, one solid at common temperatures, and the other liquid and highly volatile, besides the bodies of the extractive or apotheme class.

With respect to the plumbago, I am led to believe that the amount of carbon in a given bulk is generally greater than that due to the same bulk of the metal removed, and that in such cases the additional carbon has been deposited by decomposition of the carbonic acid contained in the water. The present, however, is not the place for incomplete researches, which those belonging to this branch of my subject are, and as to which I hope at some future time to lay further results before the Association.

319. The rusts removed from the several classes of specimens after the first immersion have been submitted to chemical examination; their compositions do not differ from those given in the preceding Reports, and vary with the time of formation.

Omitting the accidental substances introduced either from the iron or the water, they are all hydrated oxides and carbonates of iron, and tend, in proportion to the duration of reaction, nearer and nearer to approach the formula $2\,Fe_2\,O_3 + 3\,HO$, becoming in fact artificial brown hematite, more or less mixed with $Fe\,O + C\,O_2$, or spathic iron ore. When very old these rusts appear to lose constituent water and become "fer oligiste;" they are imperfectly crystallized; such I found to be the case with some taken from a bar on one of the towers of York Minster. They always give traces of ammonia. When formed in foul sea water, they generally include microscopic crystals of iron pyrites, and always in small quantity basic salts (sulphates and chlorides), with earthy carbonates formed by decomposition of the saline contents of sea water.

320. Since the publication of my last Report, a fact long doubted has been ascertained by myself and by others, namely, that water, when in the state of steam and under considerable pressure, is slowly decomposed by a surface of iron at temperatures far below visible ignition, even as low as about the melting point of lead, producing (as in the well-known case at the temperature of ignition) the magnetic oxide of iron. This has been proved not only in Perkins's closed tubes for heating buildings by hot water, or rather steam, but in a high pressure steam-boiler working at 65 lbs. per square inch by myself.

This decomposition appears always to go on in steam-boilers where the inner coating of deposit or sediment causes a plate to overheat, as in such cases oxide of iron is found lining the interior of the boiler; at that spot the deposited salts are probably decomposed here also in part.

321. No mode of coating with zinc appears capable of preserving iron from the action of boiling salt water; on the contrary, the zinc oxidates with unusual rapidity and the iron is not preserved.

322. There is a great difficulty in making any experiments of practical value or accuracy upon the questions proposed (2nd Rep. 166, &c.) as to the temperature of the boiling sea water in marine iron steam-boilers, or what is the same thing, the degree of saline concentration at which the maximum corrosion takes place. From various circumstances attending the working of marine boilers, the waste of fuel appears to increase rapidly with the concentration of the water beyond a certain point.

	A.	B.	C.	D.
Chloride of sodium	2·50	16·00	25·50	20·80
Chloride of magnesium	0·35	0·46	1·07	4·85
Sulphate of magnesia	0·58	0·80	1·48	9·50
Carbon, lime and magnesia	0·02	0·00	0·00	0·00
Sulphate of lime	0·01	0·30	0·00	0·00
Water	96·54	79·79	69·14	64·85
Sulphate of soda	0·00	2·65	2·81	0·00
	100·00	100·00	100·00	100·00

The composition of sea water being on the average represented by the column A, specific gravity = 1·0278. When the water in the boiler has been concentrated to the specific gravity 1·140, its composition is shown in column B; and when it has arrived at the density 1·220, it has the composition in column C; finally, when the greatest part of the common salt has deposited, the supernatant fluid has the composition in column D. Such are the accurate Berthier's results.

I believe the greatest amount of corrosion goes on in iron boilers (irrespective of injury done by deposits) after sea salt has begun to deposit freely, when the boiling temperature is about 232° Fahr., combined air not being present in the water, and hence, as far as corrosion is concerned, the object of the engineer is to work at as low a point of concentration as possible, which comports well with all the other contingencies of the case. It would be desirable that the feed-water of marine boilers were heated to above 190° Fahr. before entering them, and means provided for the escape of the air disengaged, which now enters the boilers and aids much in corrosion. This could easily be done by Maudsley and Field's beautiful arrangement of their feed and brine pumps. On this branch of the subject, however, I hope hereafter to present further and more complete results.

323. In Table XI. is given the results of corrosion of wrought iron in voltaic contact with the alloys of copper and zinc, and in Table XII. those with copper and tin. The alloys are the same as those whose reactions are given in Tables IX. and X. of second Report, with which the present tables coordinate.

Corrosion of wrought iron is accelerated by the presence of either brass or gun-metal; most so by the latter. With equal surfaces and conditions, copper produces greater corrosion than any of its alloys with zinc. Most of those which constitute the metals used in commerce, however, do not greatly accelerate the corrosion of wrought iron.

All alloys of copper and tin do accelerate it considerably, and even more than copper itself, while tin produces a still greater effect than copper; thus in most respects wrought iron is acted upon by air and sea water in presence of these alloys in a similar way to cast iron.

These tables now give numerical measures of the amount of loss of metal that will occur in practice in the given conditions. The results obtained long since by Sir H. Davy, as to the small amount of positive metal requisite to protect copper sheathing, indicate that within very wide limits in the relative proportions of the iron, to either the brass or the gun-metal, these results will be very nearly exact. In the present case the surface of wrought iron was always = 3·07 square inches, and of the brass or gun-metal = 1·99 square inch, and the experiments were made in vessels containing a proportionally large volume of sea water, and frequently renewed.

324. In Table XIII. the *average* loss by corrosion is given of all the varieties of cast iron at the second period of exposure of 732 days, and of the wrought iron and steel exposed for the same period, but for the first time, and also of both cast and wrought iron exposed to the weather; and in general the average results of the whole investigation, reduced into form for practical use, will be found in this and the two following tables. Table XIV. gives at one comparative view the results of all the classes of experiment.

325. In Table XV., which coordinates with Table VIII. of second Report, the average results for wrought iron and steel are extended to a period of a century for clear sea and fresh water, and for exposure to weather, &c. The numbers here give absolute measures of the loss of metal taking place in the several conditions, and from the extended base of induction from which they have been obtained, may, I think, be relied on in practice.

326. In each of the classes of experiment will be found included some made for the same lengthened period of 732 days, or about two years, on iron zinked in the ordinary way or "galvanized," and on iron coated with the zinc paint before spoken of (2nd Rep. 195). These results quite confirm the statements made in my second Report respecting these modes of protection; in every case zinking is but a partial preservative to iron in any sort of water.

Referring to Table XIII. it will be seen, that in clear sea water the corrosion of such zinked iron is rather more than one-half of unprotected iron in like conditions, while in foul water, whether fresh or salt, it is fully as great. In fact, in foul water the zinc becomes wholly converted into a black, brittle, crystalline crust, which is found to be sulphuret of zinc united to sulphuret of iron, in fact to be an artificial blende, having the composition $(Zn + Fe) + S$.

327. Zinked iron exposed merely to the weather, however, seems to be more permanently protected; and it does appear that a coat of zinc, although thin, if its integrity be not injured mechanically, will protect iron from rust when exposed to the ordinary atmospheric influences.

328. Zinc paint appears to be, as predicted, an extremely durable covering, more so than any one tried, except the asphaltic varnishes or coal-tar laid on hot; it is desirable its use should become better known, and be extended to all

large engineering structures, iron bridges, viaducts, &c., in place of the perishable "best white lead" paint usually prescribed by the engineer's specification.

329. Since the publication of the previous Reports much attention has been excited by the new method of zinking patented by Messrs. Elkington and M. Ruolz, as connected with their gilding processes, for which they have since received the prize of the French Academy. For a complete account of their highly important improvements, not merely in gilding or silvering, but generally in the means of covering any one metal almost with any other, reference must be had to the elaborate report presented to the Institute on this subject by M. Dumas. These methods consist partly in the use of certain complex metallic solutions varying with the metals engaged, principally double chlorides and cyanurets, and partly in using these in connexion with the voltaic battery. By these beautiful and economical processes, gold, silver, platina, copper, tin, cobalt, nickel and zinc may be precipitated upon the surface of various metals, and amongst them upon cast iron, wrought iron or steel at common temperatures.

The coating formed is very thin and perfectly incapable of giving any permanent protection to iron immersed in water or exposed to abrasion, but I have no doubt of its capability of preserving completely iron in any of its states, in moderately dry air, and to a great extent also when exposed freely to the weather. The method possesses the important advantages of being applicable to very minute or highly wrought articles in iron, to which zinc could not be applied in a liquid form by heat without destroying their beauty, or rendering them brittle by alloying with the iron all through, and also to articles so large and unwieldy that no operation involving a high temperature or change of place could conveniently be performed on them. Thus statues cast in iron may, by Elkington and Ruolz's processes, be covered with zinc standing on their pedestals, and the coating even periodically renewed, there being no difficulty in forming around them a stanch vessel to contain the required solution. For every work in iron applied to architectural construction, and only exposed to atmospheric moisture and not liable to abrasion, this method is most suitable; as for cast-iron balustrades or cornices, internal cramps and ties in walls, wire for ropes or for suspension-bridges, lightning conductors, iron wire-gauze, &c. But I am convinced, from the results given in this and the preceding Report, that no mere covering of zinc alone, however laid on, will be completely effective in water, and hence many of the applications, to cannon shot for instance, proposed by the report of M. Dumas, are such as the invention of Elkington and Ruolz will not answer. It is scarcely necessary to repeat, that none of the other known metals, except zinc, capable of being applied by these methods, are admissible where the coated surface is liable to abrasion. Zinc and certain of its alloys protect, on two grounds, *as a sheathing*, liable to be more or less destroyed, and *voltaically* in proportion to the electric energy developed, and whether the integrity of the covering metal be broken or not; but metals electro-negative to iron stand in a different predicament.

Of Iron Ships.

330. The durability of iron ships has become one of the most important questions involved in the present inquiry, from the rapid extension which this novel branch of naval architecture has received, and is still receiving. Amongst other considerations as to their fitness for distant voyages and their economic adoption, is that of their durability in respect to corrosion as compared with timber-built vessels, their relative liability to "fouling," and what are the means we possess of preventing or retarding both. If the former,

viz. the durability, be ensured, the vessels remaining clean under water is nearly, if not wholly attained, for both marine animals and plants adhere with obstinacy to the oxidized iron of a rusty ship's bottom, on which they thrive and multiply, while to clean iron they will scarcely attach themselves.

From the importance of this subject I have been induced to give it a very particular consideration, and propose here to enter somewhat fully into the principal agents of corrosion of iron ships, the directions in which these are found, or may be expected, to act most destructively; to describe the peculiar methods which I have been led to devise for preventing corrosion, and also those for preventing the "fouling," which is admitted by the most sanguine advocates of iron ship-building to be at present the salient evil of the system. This matter has acquired increased importance from the recent discovery of Professor Daniell of the existence of sulphuretted hydrogen in the sea water of the tropics, which our previous experiments show acts most destructively on iron, as well as on the copper sheathing of timber vessels.

331. The lower part of an iron ship's floor is exposed to putrid bilge-water (if permitted to accumulate); this, on grounds already stated, is an agent of great corrosive power, and when heated, as beneath the boilers in steam-vessels, its effects are greatly increased, as far as action from the inside is concerned; therefore the floor and futtocks may be expected soonest to require restoration. This I am informed is actually the case in those thin sheet-iron "fly-boats" used for passengers in Scotland and Ireland on the canals.

A remedy for this suggests itself which it would be highly desirable to make trial of, which could be of no inconvenience, and if successful, would have the additional advantage of destroying all smell of bilge-water in a vessel and of preserving her floor at all times sweet.

It has been before remarked (1st Rep. 49, &c.) that a small quantity of an alkali in solution, even in salt water, is capable of arresting oxidation of iron; it is highly probable that an alkaline earth-lime for instance in solution possesses the same power, indeed Payen's experiments make this certain; there would be no difficulty to keeping lime-water in the place of bilge-water over the floor of an iron ship, to any desirable degree of saturation. The ship's well being periodically pumped out dry, fresh water let in, and a few lumps of dry lime dispersed, a fresh supply of lime-water would be kept up, which would not only preserve the bottom, but destroy the putridity of the bilge-water, of which some will be found even in the stanchest vessel. No injury would be likely to result to the few timbers which would be exposed to its contact.

332. Exteriorly the action of air and water will be greatest just between wind and water, and abreast of the paddle-wheels in steamers, where the constant splash from the paddles strikes, and wherever the shell of the vessel is heated by the contact or proximity of the boilers, &c., but the difference in other parts of the hull is not likely to be considerable unless in very fast-going vessels.

333. It has long been an opinion amongst those concerned in iron ship-building, that "an iron vessel when kept in constant use is not only free from oxidation, but presents no more appearance of corrosion than railway-bars, which (say the advocates of this doctrine) are well known to remain uncorroded so long as the carriages continue to roll over them." "If the iron ship be kept in constant use, *i. e.* in constant motion through the water, there is no appearance of deterioration; but lay her up for a few months, and the usual appearances of atmospheric action become visible, accompanied by a rapid corrosion of the points exposed." With respect to this singular opinion as to railway bars, we shall have more to say presently; what analogy subsists however between a railway bar and an iron ship it is hard to see. I do

not doubt the fact that an iron ship kept constantly in motion through the water will present much less *signs* of corrosion than she will do if laid up for an equal time, but the fact does not warrant the conclusion; on the contrary, this fact rightly interpreted is the surest possible proof, and that too from the testimony of those most advantageously circumstanced for judging, that rapid corrosion does take place.

It has been heretofore shown, that when iron oxidates in sea water, the rust, when first formed, is soft and pulverulent; it has also been shown that every metal, iron included, is electro-positive to its own oxides; in other words, that the peroxide of iron formed acts as an acid towards the iron upon which it lies, in the same way exalting the rate of corrosion as the plumbago formed on cast iron has been shown by the present set of experiments to do upon it.

Now it is admitted that an iron ship at rest does corrode: if so, peroxide of iron is formed if the ship continue long at rest. This coat of oxide gets harder and forms a scale of oxide, which yet more promotes the rate of corrosion; but if the ship be kept in motion, the oxide formed, soft and pulverulent at first, is *swept off* by the passage of her sides through the water nearly as fast as it is formed, and hence, while corrosion is still going on, the exposed surface of iron, when examined, presents a clean and *apparently* uncorroded appearance.

Thus it is not true that an iron ship constantly in motion is incorrodible by sea water; on the contrary, corrosion does go on, and just at whatever rate the conditions of exposure warrant, in a surface of iron whose oxide is removed nearly as fast as it is formed, that is to say, which is exposed only to the corroding effects of the salt or other water, &c., and not to this together with the effect of its own peroxide; but it also follows, from the explanation above given of the phænomena, that the real rate of corrosion of an iron ship is less, and probably a good deal less, while she is kept in motion than while she may be at rest; and for the same reasons her tendency to "foul" is less while in motion than at rest.

334. By others it has been fancied that magnetism in some occult way interfered with corrosion in iron ships. There is no doubt that every iron ship becomes a magnet by induction from the earth, but the intensity will depend upon the ship's bearing, at any moment, as well as upon other obvious conditions. Admitting however that an iron ship were at all times a permanent magnet, no known fact warrants the supposition that its rate of corrosion would be in the slightest degree altered thereby (1st Rep. 66).

The experiments cited by Levol, and alluded to in 1st Rep. 67, as apparently leading to a different conclusion, I have since found do not sustain the view of that author. The deficiency in rate of precipitation, &c. observed by him, arose from mechanical impediments introduced by the evolution of gas bubbles, and affected by the different position of his wires in the solution, and had nothing to do with their magnetism.

335. I therefore look upon it as perfectly certain that iron vessels corrode just as any other mass of iron in similar conditions will. I would add, that no *mere inspection* of surface is sufficient to determine in this case whether oxidation has taken place or to what extent, nor can any sufficiently precise determination of amount of corrosion be obtained by drilling holes through the plates and *measuring* their thickness. This method might give some answer after a quarter of a century's corrosion; but for any moderate period no correct data as to the loss of metal can be had, but by a plate of large size *and known weight*, attached to the ship's hull by rivets or screw-bolts, detached after exposure and *again weighed*; and this experiment has not to my knowledge ever yet been made.

336. As the hulls of iron ships cannot be ordinarily got at to keep them uniformly covered with any common paint or varnish (which have however alone but a limited palliative effect in preventing corrosion), such vessels should in all respects be viewed with reference to corrosion, as if the iron was always quite bare; and if so, Table XV., before given, affords data for determining their duration if *wholly unprotected*, but as we shall see hereafter, iron vessels may be so treated, that in regard to corrosion it is difficult to assign a limit to their durability, which it is generally admitted depends simply on the question of corrosion.

337. The plates of an iron ship are likely in general to be corroded most round the rivet-heads, both outside and inside, and adjacent to any spots where the plates have been *hardened* by hammering or bending, or in any other way have had their homogeneity destroyed, and least round the bows, &c., where the oxide formed is swept off by the ship's motion through the water.

338. The contact of oak timber especially, and generally of all timbers which contain tannic or gallic acids, is extremely injurious to iron, and for keelsons, &c., or other timbers in contact with iron and water, teak should always be used in preference, which does not act at all, or but very slightly, upon iron. The bolts and nails of a gate of the fort at Canara, East Indies, after having been exposed to the weather for half a century, were found as sound as when put in: the gate was of teak. In the "Chiffone" frigate certain teak planks had been bolted to her sides; on subsequent removal the iron was sound and uncorroded in the teak, but eaten through in the oak.

339. This injurious effect of oak timber as applied to iron ship-building, might however probably be completely obviated by steeping the timber, prior to insertion, in a solution of sulphate of iron, which would engage the whole of the organic acids which act so injuriously upon iron. The oak would become black from the gallate and tannate of iron formed in its pores; its durability would most probably be increased fully as much as by steeping in sulphate of copper, for which, as a mode of preventing dry-rot, a patent has been obtained, and there is no reason to suppose that the timber would suffer any deterioration in toughness, while it would certainly become harder.

340. Kyanized timber of all sorts is destructive to iron in sea water to a prodigious extent; a portion of the corrosive sublimate (whether more or less changed) contained in the pores of the wood, is decomposed by the contact of the iron, and the quicksilver reduced to the metallic state, which, by its powerful electro-negative relation to iron, promotes the corrosion of the latter. The actual amount of corrosion on best Staffordshire iron, by my experiments, when in sea water and in contact with kyanized oak, amounted in two years to a depth of 0·122 of an inch of iron removed all over the surface, while the same iron freely exposed to the sea water alone, lost not half so much in the same time. Indeed the utility of kyanizing timber which is to be immersed in sea water appears very dubious, even if it were in this respect harmless; for M. Lassaigne has shown that whatever be the nature of the combination which the corrosive sublimate forms with the albumen of the wood, it is soon washed out, being soluble in salt water; and I have already stated that, in timber freely exposed in sea water, kyanizing is no protection against marine boring animals, kyanized oak being eaten through, two inches thick, in about two years, by the *Limnoria terebrans*, in Kingstown Harbour.

341. Of course the contact of a metal electro-negative to iron, as lead or copper, with iron ships, either exteriorly or interiorly, should be avoided, and when it is inevitable, increased scantling should be given to the plates, &c. at and around the spot.

The contact also of brass should as much as possible be avoided; but the injurious effects of brass depend much upon the relative proportions of its constituent metals, and by a proper choice in this respect may be made very small. (See Tables, 2nd Rep. IX. and X., and 3rd Rep. XI. and XII.) Brass or the alloys of copper and zinc, are to be preferred to gun-metal or those of copper and tin, *all* of which greatly promote the corrosion of iron when in contact with them in a menstruum.

342. It is a good palliative when copper or brass *must* be in contact with the iron, as in the flanges of sea-cocks, &c. in steam-vessels, to interpose a thickness of patent felt, saturated in boiled coal-tar or in wax, or other non-conducting substance; no interposition of "short iron pipes" or other metallic matters, unless masses of zinc, will be of any use; and the effect of local corrosion thus produced, especially about the engine-room and boilers in iron steamers, demands the most scrupulous caution, much more than appears yet to have been given it, gun-metal sea-cocks, copper blow-off pipes, &c. being at present in general attached directly to the iron hull, which are certain soon to cause the iron plate round them to be eaten away, and thus the vessel is rendered leaky in a vital point and probably at an unexpected moment. The application of a thick zinc flange outside the ship's side or bottom, at the junction of such a cock or pipe, would be a remedy, but would promote fouling; increased local scantling, and non-conducting flanges between the electro-negative metal and the iron, are most to be commended.

343. There are several substances found in commerce, the contact of which with the iron of ships, when carried as loose cargo, is more or less injurious, and unless an effective method of protection be adopted, such articles should not be taken in iron vessels but at commensurate freights; some of these may be named, as pyritose wet coal, sulphur, sulphur stone, gypsum, galena, copper ore, or other metallic sulphurets, when wet; alum, salt, bleaching salts; acids of all sorts, when not rendered secure against escape; wet bark for tanning, or other matters containing gallic or tannic acids, &c.

344. The following extract from our Tables gives the relative values of several of the principal sorts of wrought iron and steel found in commerce, in respect to durability in clear sea water; their relative rates of corrosion are *directly* as the numbers attached to each, and hence the values of the several sorts of iron, &c. for ship-building are *inversely* as those numbers.

Make of Iron.	Inverse Relative Value.
Common Shropshire bar	36·14
Tilted cast iron	13·38
Cold short bar, Staffordshire	13·27
Shear steel, soft	12·28
Best bar iron, Bradley	12·05
Spring steel, tempered	11·81
Blister steel, soft	11·72
Best bars and plates, Doulais (hot blast)	10·83
Swedish iron, Dannemora	10·82
Red short bar, Staffordshire	10·78
Common plates, Banks	10·60
Common Shropshire bar, case hardened	10·14
Best plates and bars, Forest of Dean	10·08
Cast steel, as hard as possible	9·38
Best bars and plates, Doulais (cold blast)	8·85
Low Moor plates	8·55
Best faggoted scrap iron	2·52

From the foregoing table it is obvious that plates rolled from scrapped iron would be the most durable for ship-building; the Low Moor comes next to these; and to these again, the plates from South Wales.

345. I now proceed to make some observations upon one or two of the methods of protection for iron which have been recently published, before giving the details of that which I have proposed.

The whole of the various methods that have been from time to time proposed for protecting iron from corrosion, may be divided into two classes: those which protect the iron by a mechanical covering, more or less perfect, and itself not acted on by the corroding agent; and those wherein, by the contact of some other body, a change is produced in the electric or chemico-polar condition of the iron with respect to the corroding agents, such that they cease to be so with reference to *it*.

To the first class belongs the whole tribe of paints and varnishes, and every attempt to cover or *sheathe* the surface of the iron with another metal which is electro-negative to it. The principal methods of this class which have been recently patented, are those of Miles Berry (a communication), for coating iron with alloys of zinc and copper by cementation (May 1838, Newton's Journal, conj. series, vol. xv. p. 91); Neilson's (of Glasgow), for coating iron with brass, by dusting the interior of the mould with brass filings before the metal is poured in, &c., a process absolutely useless; and Joseph Shore's, sealed March 1840 (Rep. Arts, No. 84, December 1840), for precipitating copper or nickel on iron by Spencer's electrotype process; and Elkington and Ruolz's process, already spoken of, patented in December 1840, which includes both classes of protection.

To this class also Wall's (of Bermondsey) process, so much brought before the public, may be said to belong, inasmuch as (although, with reference to zinc or copper, this process may produce a change in the chemical relations of those metals to air and water) it has no such effect upon iron, and merely acts upon it as an imperfect but most expensive paint or varnish.

346. The principle of the second class has been already fully pointed out in preceding Reports, and its conditions experimented on and stated. It has been stated that Sir H. Davy, Edmund Davy, Pepys and Sorel, long since invented or applied this sort of protection to iron.

The principal inventions dependent upon this method which have been patented, are those by H. W. Crauford (sealed April 1837, Rep. Arts, N. S. vol. ix. p. 289), and Fountainmoreau's (sealed May 1838, Newton's Journal, conj. series, vol. xvi. p. 289). These two patents are in fact one; they are essentially the same, differing only in certain details of application, &c. They both consist in the application of a thin coating of zinc to the whole surface of the iron, by dipping the iron into fluid zinc, when properly cleaned beforehand, or by coating it with a paint, or rubbing it, or lapping it up in a powder of metallic zinc.

Of these various methods not one is completely effective, the causes of which have been already fully discussed throughout these Reports.

347. The paint made of powdered zinc, and Wall's mercurial paint have no efficacy of an electro-chemical kind whatever towards iron. They differ in no respect from any other paint in being towards *it* mere mechanical coverings, more or less perfect. The results of experiments on the zinc paint have been already given. Wall's patent, which describes an absurd and roundabout process that reminds one of the recipes of the alchymists, and can scarcely be the result of chemical knowledge, is, when stripped of its useless encumbrances, simply a mode of making a mixture of several salts of iron and mercury, chiefly sesquichloride and sesquioxide of iron, and subchloride and subnitrate of mercury, with probably suboxide of mercury, which

being obtained, the whole is ground into a thin "bodyless" paint with linseed oil; when the paint is long exposed to sea water in contact with zinc or copper, it is *possible* that a small quantity of the mercury may be reduced to the metallic state, and may amalgamate the surface of a *zinc* or *copper* plate in contact with it; but it cannot, under any conceivable circumstances, have the smallest protective power over iron, beyond that which the linseed oil alone gives, the greasy coating of which probably enabled the patentee's prepared plates to resist the acids, &c. applied by those whose testimonials to that effect have been published. In some specimens of zinc and iron which I received prepared according to this process, I found there was not the slightest protection from corrosion when once the greasy film of oil was removed.

348. I now pass to the second class of methods of protection. Zinc is the only known metal that can be practically used as an electro-chemical protector to iron; it can be applied, in a massive form, locally or at particular centres of action, or it can be diffused in a thin coat or zinking over the whole surface.

There is no considerable difficulty in the first mode of application in most cases, but it is, after the lapse of a greater or less time (generally only a few weeks), nearly useless, from one or both of two causes. Zinc is so slightly electro-positive to iron, that its protective power is nearly destroyed whenever a few spots of red rust have formed anywhere upon the iron it is in contact with; the peroxide acting as an acid towards its own base in both fresh and sea water, the surface of the zinc gets covered in the latter with a hard crystalline coat of hydrated oxide of zinc and of calc-spar, which retards or prevents its further corrosion, and thus permits the iron to corrode. The details of these reactions have been given at length in preceding Reports.

349. These phænomena also occur when the surface of the iron is all zinked over; but the insurmountable objection to zinked iron is, that in about two years nearly the whole of the thin coat of zinc is oxidized and removed even in fresh water, and in less time in sea water; further, the tendency of zinc to oxidate when fluid and at a high temperature, say 700° Fahr., is so great, and the methods of cleaning the surfaces of iron to be zinked heretofore practised so imperfect, that the surface of iron is never perfectly covered; and wherever an uncovered spot occurs and is exposed to air and water, after a time red oxide is formed, with the results above stated. Zinc, alone or unalloyed, at its fusing temperature in process of working gets its oxide mixed up with the metal, which adheres in minute patches to the iron, every one of which becomes a centre of subsequent oxidation.

350. I will not attempt here to enter upon the theoretical consideration of the process about to be described, but confine myself to a description of the methods to be pursued and the results obtained. These methods of preventing the corrosion of iron, whether cast or wrought, or of steel, are applicable to articles formed of these metals of whatever sort; and the methods of preventing the "fouling" of iron vessels, or vessels sheathed with iron, are applicable to all articles of these metals immersed in sea or fresh water; I therefore propose their application to all manner of articles of cast iron, wrought iron, or steel; but as by far their most important and valuable application is to the protection of ships built of iron, I will confine my description to the methods of applying my processes to such only, from which may be readily understood how it is to be applied to all other articles of iron, &c.

351. By the word "fouling," as applied to ships, iron buoys, floating beacons, &c., is meant the attachment and adherence to their surfaces, when immersed in sea or certain fresh waters, of various marine or freshwater animals of the molluscous and testaceous classes, and of aquatic plants.

352. The method of preventing corrosion and "fouling" of iron vessels consists of three principal operations; the first of which is designed to prevent corrosion, the second aids the former, and also prevents the first part of the process being afterwards interfered with by the third operation, which has reference solely to the prevention of "fouling." Hence, for all other articles of iron, except certain of those immersed in sea or fresh water, the first two operations are alone requisite, and in some cases the first only. I proceed to describe in detail the modes of performing the several operations.

353. The first consists in covering the iron with a particular alloy of zinc in fusion; for this purpose the iron surfaces require to be previously cleansed from adhering oxide. The boiler-plates, angle-iron, &c. to be used for ship-building should not be permitted to acquire any red rust previous to the operations about to be described; and if required to lay by for a considerable time previous to use, or to be transported to a distance, should be rubbed over with drying oil or other greasy matter to preserve them temporarily from rust: this oily coating may be afterwards removed by immersion in any alkaline ley.

354. The plates or other pieces of cast or wrought iron or steel are to be immersed on edge (or in such a position that the detached scale of oxide can readily fall off), in a suitable vessel of wood, pottery, stone or lead, containing dilute sulphuric acid (specific gravity about 1·30), or dilute hydrochloric acid, specific gravity about 1·06 at 60°, formed by diluting these acids respectively, as they are usually found in commerce, with rather more than an equal bulk of water.

The diluted acid is best warmed, which may be conveniently done by a steam-jacket round the vessel, or by blowing steam into the acid, as it is desirable that the scale of oxide should be detached as rapidly as possible from the surface of the iron. The acid vessel, in operating on the great scale, is best formed so that the lower portion of acid and the scales which have deposited can be occasionally withdrawn, to prevent waste of acid or increased length of time in the cleansing process. The iron must be *wholly immersed*, and the bubbles of gas formed on its surface must be free to ascend in the fluid and escape.

355. As soon as the scale of oxide has become detached or loosened from the iron, the plates or other pieces are to be removed from the "cleansing bath" and washed with cold water. The surfaces are now to be thoroughly scoured by hand or by power, with sand or emery, or with pieces of grit stone, while exposed to a small running stream of water, until they appear quite clean, bright and metallic.

356. The plates or other articles of iron are now immediately, and without being permitted to dry, immersed in the "preparing bath," in which they are to lie until about to be covered with the alloy of zinc to be hereafter described. The fluid which forms what may be called the "preparing bath" is made in the following way:—To a saturated cold solution of chloride of zinc is to be added an equal bulk of a saturated cold solution of sal-ammoniac, and to the mixed solutions as much more sal-ammoniac in the solid state is to be added as they will dissolve; or these solutions may be made and mixed hot, and the solid sal-ammoniac then added, if thought more desirable, but the addition of more water on cooling is then requisite. The "preparing bath" may also be formed of sulphate of zinc and sulphate of ammonia, or acetate of zinc and acetate of ammonia, or of any other soluble double salt of zinc and ammonia, or salt of manganese and ammonia; the nitrates of zinc and ammonia are the least advantageous, but none answer the purpose so well as the above-described chloride of zinc and sal-ammoniac. No free acid should be present in these solutions.

357. The iron, cleansed by the previous operations, is immersed in this solution, contained in vessels of wood or pottery, or stone, at common temperatures; as soon as the surfaces of the cleansed iron appear covered all over with minute bubbles of gas, it is in a fit state to be submitted to the final operation of immersing in the metallic alloy with which it is to be coated; but the iron, when once cleansed, may be permitted to remain in the "preparing bath" for any moderate length of time, without injury to the subsequent process. The "preparing bath" becomes therefore a convenient receptacle for depositing and preserving the cleaned or polished iron in until ready for coating with the alloy.

358. The next part of the process consists in covering the iron with the preservative alloy, which is to be prepared in the following manner:—Zinc is to be melted in a suitable vessel, which is best of pottery or stone; and when in fusion mercury is to be added to it, in the proportion of 202 parts of mercury to 1292 parts of zinc, both by weight; that is, 40 atoms of zinc to 1 of mercury, or thereabouts. These are to be well stirred or mixed together with a rod of dry wood, or of iron coated with clay. To the above alloy is now to be added either potassium or sodium, in the proportion of one pound to every ton weight; the alloy of either will answer the purpose, but I prefer sodium, as more easily obtained and more manageable. These metals are usually preserved from oxidation in naphtha, or some other fluid not containing oxygen. They are to be removed from this in small portions, not more than half an ounce at a time, placed in a small inverted cup of wood formed on the end of a stick and thrust rapidly below the surface of the alloy of zinc and mercury, with which either may be made thus to combine easily, and without loss or combustion of the alkaline metal. The triple alloy thus formed of zinc, mercury and sodium, or potassium, after having been again stirred and mixed with the dry wood rod, is ready for coating the prepared iron when immersed in it. The combination of these metals is facilitated, and their oxidation on the surface retarded, by strewing upon it some of the salts contained in solution in the "preparing bath" when in a dry state.

359. The plates of iron or other articles are now to be taken up out of the "preparing bath," permitted to drain for a few seconds, and immediately, while still wet with the liquor, immersed in the fused alloy; and as soon as they have acquired its temperature, which should not be raised higher than is necessary for fusion, they are to be withdrawn again edgewise, and will be found covered with a perfectly uniform and coherent coat or surface of the alloy.

360. The affinity of this alloy for iron is so intense, and the peculiar circumstances of surface induced by the preparing bath upon the iron presented to it are such, that care is requisite, lest, by too long an immersion, the plates or articles of iron should be partially dissolved; and where the articles to be covered are small, or their parts minute, it is necessary, before immersing them, to permit the alloy to dissolve or combine with some wrought iron, in order that its affinity for iron may be partially satisfied, and so this risk be avoided. The alloy will, at its proper fusing temperature, which is about 680° Fahr., dissolve a plate of wrought iron of an eighth of an inch thick in a few seconds, and form with it a quadruple alloy.

More or less mercury and more or less of the alkaline metals may be used in forming this alloy, but the proportions given are those I have found best, as the alloy is permanent at its temperature of fusion; *i. e.* no mercury is lost by volatilization, nor does the alloy show any inconvenient tendency to oxidation, much less indeed than common zinc does at the surface, which is in the case of the alloy to remain covered with any oxide produced, and with the dry salt, the double chloride of the preparing bath transferred to it on the pieces of iron, as these defend it from the action of the atmosphere. It is desirable that the melting vessels should be as deep, and expose as small a surface, as the nature of the articles to be immersed will allow. At the moment of immersion of a plate or other article of iron, the surface of the alloy is to be cleared of all dross or oxide by a wooden skimmer.

361. As soon as the iron is withdrawn from the alloy it is to be plunged into cold water and well washed therein. The surface of the iron is now in a condition to resist corrosion.

362. By the addition of a larger portion of mercury to the before-mentioned alloy of zinc, mercury and sodium, or potassium, cast or wrought iron or steel may be coated therewith at a lower temperature, or even cold, by simple contact accompanied with friction; but a smaller quantity of mercury than that before given will often be found most convenient.

363. In the case of iron ships the foregoing operations are best performed upon the plates and ribs, after they have been all bent and fitted to their places, and the plates riveted together into large pieces of eight to ten feet square or more, which, when again put "into frame," or placed in their respective positions in the ship's hull, are to be united by rivets countersunk from the outside, and hence closed inside the vessel. The countersunk heads of these rivets should be also coated with the alloy; and I have mentioned in detail elsewhere how these may be heated for riveting without injuring the alloyed head.

364. The hull of the iron vessel being thus completed and wholly covered with the alloy, is now to receive a coat of varnish all over of the composition about to be described, and which is best laid on with a spatula, or thin flexible blade of iron, as a brush produces minute air-bubbles, which leave spaces uncovered on the drying of the varnish.

The varnishes described will dry or get hard and coherent at ordinary temperatures, but where convenient it is desirable to expose them for some hours to a temperature of about 300° Fahr., which gives them greater adhesion and durability.

365. To form the varnish No. 1, take 50lbs. of foreign asphaltum, melt and boil it in an iron vessel for three or four hours, adding gradually, in fine powder, 16lbs. of red lead and litharge ground together in equal proportions, with ten imperial gallons of drying linseed oil; bring all to a boiling temperature, melt in a separate vessel 8lbs. of gum anime (which need not be of the clearest or best quality), add to it two imperial gallons of drying linseed oil boiling, and 12lbs. of caoutchouc softened or partially dissolved by coal-tar naphtha (as practised by the makers of waterproof clothes); mix all together in the former vessel and boil gently until, on taking some of the varnish between two spatulas, it is found tough and ropy. When this "body" is quite cold, it may be thinned down with from thirty to thirty-five gallons imperial of turpentine or of coal naphtha.

This is the best varnish I am acquainted with for the purpose of covering iron; it is not acted on when dry and hard by any moderately diluted acid or caustic alkali; it does not, by long immersion, combine with water, and form a white and partially soluble hydrate, as all merely resinous varnishes and all oil paint do, and it is so elastic that a plate covered with it may be bent several times without its peeling off; and lastly, it adheres so fast that nothing but a sharp-edged instrument will scratch it off the surface of iron.

The varnish No. 2 is of a cheaper sort, but not quite so good. Common coal or gas tar is to be boiled in an iron caldron at so high a temperature that the smoke from it is of a yellow dun colour, or the tar is to be caused to flow through red-hot iron tubes. The boiling is to be continued until the residue is a solid asphaltum, breaking with a pitchy fracture. It is essential that the boiling should be carried on at this high temperature, as the permanency of the varnish in water depends upon the tar having been submitted to the temperature at which naphthaline is formed by the decomposition or breaking up of the original constitution of the tar.

Take 56lbs. of this coal-tar asphaltum, melt it in an iron vessel, add ten imperial gallons of drying linseed oil ground with 25lbs. of red lead and litharge in equal proportions; add to the whole, when well mixed, and after boiling together for two or three hours, 15lbs. of caoutchouc, softened or partially dissolved by coal naphtha (as before described); when cold, mix with twenty to thirty gallons of turpentine or coal naphtha, and the varnish is ready for use.

366. Either of these varnishes is to be applied over the whole surface of the iron and suffered to dry; and as this forms the final preservative coat upon all articles except iron ships, buoys, &c. requiring to be preserved from "fouling," any desirable colour may be given to it by colouring materials, which should be peroxides not acted on by air and water.

367. The last operation, viz. that to prevent "fouling," now remains to be performed upon ships, &c.; for this purpose a strong-bodied thick paint is to be made with drying linseed oil, red lead and sulphate of barytes (or white lead may be used, but not so advantageously), and a little turpentine. To every 100lbs. of this paint, when mixed, is to be added 20lbs. or thereabouts of oxychloride of copper and 3lbs. of a mixture composed of hard yellow soap, melted with an equal weight of common resin and a little water.

The colour sold in commerce originally under the name of Brunswick green was an oxychloride of copper. The Brunswick green of commerce at present is a different thing, but the oxychloride of copper may be obtained at a cheap rate by various known methods, which it is unnecessary to detail. With this paint the whole *immersed* hull of the vessel is to be coated over the before-mentioned varnish; it must then be permitted to dry and stiffen for three or four days before the ship is floated out of dock. The operations are now completed, and the hull of an iron ship so treated will resist "corrosion" and "fouling."

368. The principles upon which this method of protection rests may be thus stated:—By the use of the "preparing bath," the surface of iron, of whatever sort, is more effectually cleansed than has before been practicable, and all minute particles of foreign matter removed from the surface; and by the reactions which take place in the "preparing bath," in which *metallic amides* are formed, and hydrogen evolved at the surface of the iron, a powerful tendency is given to the iron to combine with other metals. Again, by the presence of the small quantity of sodium or potassium in the alloy, a greatly increased tendency to combine with iron is conferred upon *it*, while any minute portions of oxide, either suspended in the fluid alloy, or which have escaped the previous operations upon the surface of the iron, are reduced to metal. Thus both metals are presented to each other in a state of absolute purity and in the most favourable circumstances for combination.

369. But further, when the alloy, or generally any alloy of mercury with metals electro-positive to it, is exposed to the action of a solvent, the positive metal at the surface is first acted on, and the surface becomes shortly covered with pure mercury. The result, therefore, of the primary reaction of air and water on this alloy is, that the coating of the iron becomes covered with a very thin film of *amalgamated zinc*, which is known not to be acted on by fluid menstrua, except under peculiar conditions. I found no calcareous coating formed on such a surface in sea or fresh water. The varnish laid over this is intended as a sheathing, to give additional durability and mechanical

protection; and also in the case of iron ships, to interpose between the covering of alloy and the final coat of poisonous paint.

370. It was stated by Sir H. Davy, in his researches on the preservation of copper sheathing, that the sole cause why it did not become "foul" when unprotected was, the continual loss of substance by solution and washing away of the salts produced (the suboxide and oxychloride of copper), and that the poisonous properties of the salts produced had nothing to do with the matter. The only proof, however, given of this was, that fouling rapidly took place upon a surface of *lead* forming a portion of a coppered vessel's hull, upon which there existed an abundant production of carbonate of lead. Although fully aware of the powers of endurance possessed by the classes of animals which adhere to ships, such as those of the genera *Balanus, Otion, Ascidia, Cineras, Anatifa, Ostrea, Mytilus, Dreissena*, &c., still I doubted this conclusion, from remarking that they adhered to the surface of metals, such as zinc in a rapid state of degradation or solution in sea water, but which did not produce poisonous salts.

371. I also observed, that to perfectly clean metallic surfaces they showed little disposition to adhere; that either a thin coat of peroxide, or of calcareous matter deposited from the sea-water, was necessary to their adherence; that the testaceous animals seemed to disregard the nature of the metal to which they clung, provided they had a coating of calcareous matter to adhere to, and that the same applied, to a great extent, to the growth of sea-weeds.

372. I thence determined to make some direct experiments upon the effects of metallic poisons upon such common molluscous or testaceous animals as I could command, and for this purpose I chose the common oyster, the limpet (*Patella*), and some of the *Actiniæ* found along the shores of Dublin Bay: these were placed in glass vessels of sea water frequently renewed, and left for some time without disturbance, until it was certain that the condition of the animals was not in itself fatal or injurious to them. Then certain poisonous metallic salts were gradually introduced into their respective receptacles, such as the soluble and insoluble salts of lead, copper, mercury, arsenic, &c.

373. The results of these experiments, which were continued for a long time and made with care, showed that all these animals were more or less subject to annoyance from substances poisonous to the higher animals; that they were least affected by the salts of lead and mercury, and most so by those of copper; and that, unless present in such large quantity as to be at once fatal, the insoluble, or rather difficultly soluble salts of copper in sea water (such as the oxychlorides and the arsenite of copper) gave them much more uneasiness than the soluble ones. The poisonous matter, when difficultly soluble, was sometimes merely dropped into the sea water near the animal, at others was strewed upon a plate and the animal placed upon it. In every case, when the animal was killed, the poisonous matter (at least the copper, which was the only metal looked for) could be detected in its body after death.

374. From these experiments, I think I am justified in concluding that the other classes of "fouling" animals, whose habits are so analogous to those tried, are prevented from adhering to copper sheathing in virtue of the poisonous salts produced by the sea water acting upon it, and not merely by loss of continuity; and that in the case of the lead cited by Davy, the animals adherent must have been protected from the poisonous surface by a coat of calc-spar or carbonate of lime formed upon it, or by some other unexplained circumstance; and that hence the production of an artificial poisonous surface upon the bottom of an iron ship, a buoy, &c., would prevent their "fouling" also.

375. I also made some experiments upon the effect of metallic poisons upon sea-weeds, choosing for this purpose portions of *Fuci* adherent to small loose

pebbles, and thus capable of transfer to a glass vessel. The results here were not so distinct as with the animals, but proved that copper salts in solution were decidedly deleterious to their existence. I ascertained also that marine plants would with the greatest difficulty attach or grow upon greasy or varnished substances free from any film of calcareous matter or oxide of iron.

376. From these experiments, I have been led to propose the peculiar poisonous paint already described as a preventive to "fouling" of iron ships; it is in fact a method of bringing their immersed surfaces as nearly as possible to the condition of a copper-sheathed vessel without injury to the iron. The paint, therefore, is only a vehicle for poisonous matter, for which purpose it is requisite that it should have sufficient adhesion to resist the ship's motion, but still should have a slight degree of solubility in water, so that the poisonous matter may be taken up by the absorbent or capillary vessels of an adhering animal or plant. This latter property is given it by the addition of the resinous soap, the proportion of which must be varied to suit frigid or tropical climates. I prefer using the oxychloride of copper as the poisonous matter of this paint; indeed it is simply the formation of this salt that prevents "fouling" of ordinary copper sheathing, but other salts will answer the purpose.

377. The cost of protecting, by the methods described, the hull of an iron ship, of say 130 feet keel, materials and labour included, and preparing her against fouling, would add about ten shillings per ton to the cost of her hull, an amount quite inconsiderable when balanced against durability, safety, and speed.

378. When no attempt is made to procure complete protection from corrosion, a considerable palliative consists in heating all the plates before being put together to nearly a "black-red" heat in a boiler-maker's oven, immediately plunging them into boiled coal tar, and taking them out while still warm, so that a firm varnish may form upon them; but spots of rust soon appear even upon plates so treated.

379. It is very desirable in every iron ship, that a layer of felt saturated in coal tar, boiled to the consistence nearly of pitch, should be interposed between not only every metallic body electro-negative to iron, as before observed, but also between *every* piece of timber, of whatever sort, placed in contact with the hull below the water-line, and most especially in the bilge. Besides obvious mechanical reasons, this is important from the fact, that as soon as timber begins to decay in contact with iron and sea water, the rotten wood possesses the power of decomposing the sulphate of lime of the sea water, reducing it to sulphuret, while carbonic acid evolved from the decayed timber again decomposes the latter, producing sulphuretted hydrogen, which corrodes the iron locally with great rapidity.

380. Soft wood not only rots soonest, but decays in a way that produces these effects more rapidly than the harder timber: this fact I would press upon the attention of iron ship-builders.

These remarks might be extended, with many others of importance to the practical constructor, but for which this is not the place.

381. In conclusion, when the durability of iron vessels, as regards corrosion, and this is admitted alone to limit their existence, is compared with that of timber ships in reference to their decay, the balance undoubtedly seems at first in favour of the latter. We have examples of ships, such as the Royal William, built in 1719, lasting more than 100 years; the Sovereign of the Seas, built in 1639, forty-seven years; the Barfleur, built in 1768, more than forty-four years, &c.; but these are the rare exceptions, not the rule.

The Commissioners of Woods and Forests, in their 'Report of 1812, on Timber for the Navy,' estimated the average duration of a ship at fourteen years, while other authorities take it at twelve and a half years. Frigates, when built of American red pine, seldom lasted longer than five years, and the Ocean, Foudroyant, St. Domingo, Rodney, Ajax, and Albion, new ships, all fell to pieces from dry rot in about four years.

382. Were it the fact, therefore, that unprotected iron vessels corroded equally throughout every part immersed, we could easily calculate, by the aid of our preceding researches, the durability of a ship of given scantling, and predetermine, under such and such conditions, at what time her hull would have become dangerously thin, and might rest with the assurance that for this period the iron ship was the best and safest that could be put upon the waters; but unfortunately we have found that corrosion does not take place with perfect uniformity, as has been already pointed out; and hence, without protection, ships of iron must be always liable to the dangerous consequences of local corrosion and consequent thinning down of iron at particular spots, until at some unforeseen moment, possibly of least preparation and greatest external peril, a decayed plate is burst through and the vessel fills. The facility of introduction of water-tight bulk heads in iron ships greatly reduces the danger of such an accident, but it must always be attended with danger and loss of property, and occurring where it is most likely to happen, namely, in the engine compartment of an iron steamer in bad weather, would be almost certain to involve the loss of the ship.

The more sanguine advocates of iron ship-building have, in their anxiety to prove their durability to be such as to render protection needless, appealed to the existence of iron canal-boats of forty years of age or more, and to some of the earliest built iron vessels which have been occasionally in salt water. Most of the vessels alluded to however have been principally in fresh water, and on referring to Table XV. it will be obvious how vast a difference there is in durability of a ship of any given sort of iron, exposed to the action of sea and of fresh water. Thus, suppose a vessel of Low Moor plates; in one century the depth of corrosion would be—

	Inch.
In clear sea water	0·215
In foul sea water	0·404
In clear fresh water only	0·035

In other words, while the ship, if originally of half-inch plates, would be almost destroyed in foul sea water, it would not have lost one-tenth of its scantling in clear fresh water in the same time. These cases therefore prove nothing to the point.

383. It therefore seems to me that protection against local corrosion and "fouling" are essential to the safety and perfection of iron ships, and are alone wanting to render our future iron ships as much safer and more enduring than those of timber, as the steam ship of today is safer and more enduring than the sailing vessel of two centuries ago.

384. The mechanical methods which have been proposed for removing foulness from the bottoms of iron ships, namely by scraping with a large wooden frame drawn under the hull by suitable rope tackle, appears quite incapable of removing more than the mere exterior fringe as it were of the "foulness," or some of the larger animals when once become adherent. The force with which both animals and plants adhere to the coat of calcareous and rusty matter on an iron plate is very great, and no instrument sufficiently sharp, and pressed hard enough to the ship's hull, could probably be successfully used, unless of iron, and this would be liable not only to injure the surface, but become constantly caught against small projections of the ship's bottom.

385. But even were some methods of scraping possible, it only temporarily removes the evil, leaving its cause untouched; and that this cause is in such rapid operation, at least in some localities, as to be a most serious evil, may be illustrated by the following observations:—

Stevenson, in his account of the Bell Rock Lighthouse, mentions that the bottom of the temporary light-ship, after being newly caulked and pitched, was found covered over with mussels (*Mytili*) three and a half inches long, in three years and seven months from the time she was moored off the Bell Rock.

It is stated in the Transactions of the Wernerian Society, vol. ii. p. 243, that the spawn of the Cirrhipoda class of fouling animals became developed upon *a feather*, on which it lay before the latter had decayed in sea water, and that they will cover a ship's bottom in a few months.

These observations applied to wooden vessels, and the prevalent opinion seems to be, that iron ships "foul" even more rapidly than these do in similar circumstances.

386. The opinion that iron vessels as well as railway bars receive some hidden power of resisting corrosion when in use which they lose at other times, has been before alluded to.

387. The origin of this view with respect to rails is obscure. Wood, in his 'Treatise upon Railways,' quotes a Report of Mr. G. Stephenson, in which the following passage occurs:—

"One phænomenon in the difference of the tendency to rust between wrought iron laid down as rails, and subjected to continual motion by the passage of the carriages over them, and bars of the same material either standing upright, or laid down without being used at all, is very extraordinary.

"A railway bar of wrought iron laid carelessly upon the ground alongside of one in the railway in use, shows the effect of rusting in a very distinct manner; the former will be continually throwing off scales of oxidated iron, while the latter is scarcely at all affected."

388. This is the first notice I have found of this opinion, which has since been repeated in various quarters, but *no fact*, that I am aware of, has been given to support the view which a mere casual inspection of rails so situated suggests.

When rails lying parallel on the same line of way, but one set in and the other out of use, are examined, appearances do undoubtedly seem to support the opinion. The unused rails are found covered with red rust, often coming off in scales parallel to the surface, while those in use present a light brown or buffish coat of rust, without any loose scales. I am much disposed however to believe that there is no real difference in the amount of corrosion in the two cases, and that the difference in appearance arises partly from a *deceptio visus*, by the effect of the bright and polished upper face of the used rail (kept so by constant traffic) contrasted with the rusty face of the unused rail, and partly from the fact, that as fast as rust is formed upon the rail in use, it is shaken off by the vibration of passing trains, and blown away by the draft of wind which accompanies their motion, and that the rail is soiled and partially blackened by coke and other dust, &c.

Recently the assumed difference in rate of corrosion has received a new version; it has been stated that rails in use *do* corrode as well as those out of use, provided the traffic pass over them in both, that is in opposite directions as on a single line of way, but do not corrode if the traffic be confined to one direction. These results have been attributed to some undescribed and occult magnetic action.

389. Whether either or any of these views be correct or not I am unable at present to say, but as the subject is not only interesting in a scientific

point of view, but of practical importance, and as no correct measures as yet exist, or at least have been published, of the amount of loss of metal by oxidation and abrasion of railway bars, I have thought it desirable to institute some experiments to determine, first, whether there be any difference in the amount of corrosion of rails in and out of use; secondly, if there be any, to discover on what the effect depends; thirdly, to distinguish numerically between the loss due to corrosion, and that due to abrasion by traffic.

These experiments I have been enabled to commence on the Dublin and Kingstown Railway, by the favour of the Directors of that line, and hope soon to have others in operation upon the Ulster Railway, which is a single line, with traffic of course in both directions over the same rails. I have not as yet obtained any results (from insufficient lapse of time) which I can consider trustworthy, but so far I have not been able to recognize any distinct difference of corrosion between the used and unused rails; on a future occasion, however, I hope to be able to lay my results fully before the Association.

390. With this exception, and a few others merely of scientific interest, the present Report completes the investigation of all the more important practical desiderata on the subject of the corrosion of iron, &c. entrusted to me by the British Association, and I hope that as the information obtained by its liberal assistance becomes more known, it will be found of practical use by all who are engaged in the constructive use of iron, the substance perhaps the most valuable and important of all those with which Providence has endowed us.

Note by the Author.—Since the preceding Report was sent to press, I have learnt with satisfaction that the principles therein developed for preventing the fouling of iron ships have been already acted on; that the Iron Queen and the Ben Ledi iron steamer have been coated with a composition of tallow, bright varnish, arsenic, and, I believe, sulphur, and that in the former case all fouling was prevented; and after the vessel had made two voyages to the Tropics, she was found perfectly clean when docked on her return.

From the bottom of the Ben Ledi ten tons weight of mussels and barnacles are stated to have been removed previous to the application of the above poisonous varnish, which, although different from that I have recommended, not so efficacious, and not harmless as regards its reaction upon the iron hull, is still quite identical in principle with mine.

R. M.

June 26, 1843.

Second Course of Experiments.

TABLE I.—Box α. No. 1. containing Specimens of Cast and Wrought Iron immersed in clear Sea Water.

Sunk and moored a second time in Kingstown Harbour at the Second Buoy in from the Western Pier Head, in three and a half fathoms water, at half tide, upon a clear sandy bottom, on January 11, 1840, at one o'clock P.M. Weighed and removed again at same hour on January 12, 1842; hence immersed 732 days.

Box α. No. 1. Class No. 1. Welsh Cast Iron.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
No. of Exp. and mark of Spec.	Dimensions of Specimen.	Weight of Specimen in Grains.	Weight of Specimen after 732 days' immersion.	Total loss by Corrosion in 732 days.	Loss of weight per square inch of Surface.	Loss of weight referred to Standard Bar.	Increment of Corrosion.	Decrement of Corrosion.	Weight of Water absorbed.	Character of Corrosion.
	in. in. in.									
α 1	5×5×1	42720	42327	393	5·614	0·633	0·	1·192	0·	Uniform P.
α 2	5×5×25	11384	10895	489	8·890	1·003	0·	4·150	0·	Uniform P.
α 3	5×5×1	43452	43059	393	5·614	0·633	0·	1·672	0·	Uniform P.
α 4	5×5×25	12209	11886	323	5·872	0·662	0·	5·186	0·	Uniform P.
α 5	5×4×1	34469	34120	349	6·017	0·678	0·	3·269	0·	Uniform.
α 6	5×5×1	43200	42807	393	5·614	0·633	0·	2·142	0·	Uniform P.
α 7	5×5×25	11759	11388	371	6·745	0·761	0·	4·174	0·	Uniform P.
α 8	5×5×1	41176	40904	272	3·885	0·438	0·894	0·	0·	Local.
α 9	5×5×25	10576	10413	163	2·963	0·334	0·	3·334	0·	Local pitted.
α 10	5×5×1	41547	41090	457	6·528	0·736	0·	1·079	0·	Uniform P.
α 11	5×5×25	11169	10887	282	5·127	0·578	0·	6·300	0·	Uniform P.
α 12	5×5×1	43638	43311	327	4·671	0·527	0·369	0·	0·	Uniform.
α 13	5×5×25	12339	10949	390	7·090	0·899	0·	6·952	8·0	Local pitted, deep.
Box α. No. 1. Class No. 2. Irish Cast Iron.										
α 14	5×5×25	10479	10074	405	7·363	0·830	0·	4·158	0·	Local Plumbago.
α 15	5×5×1	40331	39687	644	9·200	1·038	0·023	0·	0·	Local Plumbago.
α 16	5×5×25	11453	11036	417	7·581	0·855	0·	3·862	0·	Uniform Plumb.
α 17	5×5×1	42695	42266	429	6·128	0·691	0·	0·099	0·	Uniform Plumb.
Box α. No. 1. Class No. 3. Staffordshire, Shropshire and Gloucestershire Cast Irons.										
α 18	5×5 ×25	11789	11387	402	7·309	0·824	0·	3·536	0·	Local Plumb.
α 19	5×5 ×1	44352	43960	392	5·600	0·631	0·	1·870	0·	Local Plumb.
α 20	5×4 ×1	34412	34141	271	4·672	0·527	0·	4·070	0·	Local pitted.
α 21	5×4 ×1	33770	33460	310	5·345	0·603	0·	2·935	0·	Local pitted.
α 22	5×3·63×1	31530	31217	313	5·843	0·659	0·	2·281	0·	Local pitted.
α 23	5×5 ×25	11900	11573	327	5·945	0·670	0·	6·927	2·0	Local Plumb.
α 24	5×3·75×1	32527	32324	203	3·690	0·416	0·	1·670	0·	Uniform.
α 25	5×3·5 ×1	28773	28288	485	9·327	0·052	0·	11·299	0·	Local Plumb.

Box α. No. 1. Class No. 4. Scotch Cast Irons.

1. No. of Exp. and mark of Spec.	2. Dimensions of Specimen.	3. Weight of Specimen in Grains.	4. Weight of Specimen after 732 days' immersion.	5. Total loss by Corrosion in 732 days.	6. Loss of weight per square inch of Surface.	7. Loss of weight referred to Standard Bar.	8. Increment of Corrosion.	9. Decrement of Corrosion.	10. Weight of Water absorbed.	11. Character of Corrosion.
	in. in. in.									
α 26	5×5×1	43961	43505	456	6·514	0·734	0·	1·526	0·	Uniform Plumb.
α 27	5×5×25	11514	11117	397	7·218	0·814	0·	2·924	0·	Local Plumbago.
α 28	5×5×1	43276	42856	420	6·000	0·676	0·	1·798	0·	Local Plumbago.
α 29	5×5×25	11527	11193	334	6·072	0·685	0·	3·300	0·	Local Plumbago.
α 30	5×5×1	43085	42604	481	6·871	0·777	0·	2·565	0·	Local Plumbago.
α 31	5×5×25	11671	11395	276	5·018	0·566	0·	4·107	0·	Uniform Plumb.
α 32	5×5×1	43334	42975	359	5·128	0·578	0·	3·000	0·	Uniform.
α 33	5×5×25	11404	11064	340	6·181	0·697	0·	6·072	0·	Local Plumbago.
α 34	5×5×1	43558	43279	279	3·985	0·449	0·	2·632	0·	Uniform.
α 35	5×5×25	11275	10910	365	6·636	0·748	0·	4·852	0·	Local Plumbago.
α 36	5×5×1	42172	41844	328	4·685	0·528	0·	2·394	0·	Uniform.
α 37	5×5×25	11265	10913	352	6·400	0·717	0·	5·107	0·	Local Plumbago.
α 38	5×5×25	11238	10747	491	8·927	1·007	0·	6·041	0·	Local Plumbago.
α 39	5×5×1	43700	43337	363	5·186	0·585	0·	0·399	0·	Uniform.
α 40	5×5×25	11147	10676	471	8·563	0·966	0·	7·143	0·	Local Plumbago.
α 41	5×5×1	42574	42275	299	4·271	0·481	0·	0·902	0·	Uniform.
α 42	5×5×25	11701	11204	497	9·036	1·019	0·	3·983	0·	Local Plumbago.
α 43	5×5×1	44269	43870	399	5·700	0·643	0·	1·627	0·	Local pitted.
α 44	5×5×25	10916	10479	437	7·945	0·896	0·	7·030	0·	Local Plumbago.
α 45	5×5×1	43184	42625	559	7·985	0·900	1·311	0·	0·	Uniform.
α 46	5×5×25	11343	10830	513	9·327	1·052	0·	5·089	0·	Local Plumbago.
α 47	5×5×1	42575	42120	455	6·500	0·733	0·426	0·	0·	Local pitted.
α 48	5×5×25	11449	10995	454	8·254	0·931	0·	3·687	0·	Local Plumbago.
α 49	5×5×1	43061	42736	325	4·642	0·523	0·	3·056	0·	Local pitted.
α 50	5×5×25	11754	11285	469	8·527	0·962	0·	4·852	0·	Local Plumbago.
α 51	5×5×1	43911	43639	272	3·885	0·438	0·	1·196	0·	Uniform.
α 52	5×5×1	43781	43277	504	7·200	0·812	0·	1·534	0·	Local pitted.
α 53	5×5×25	11381	10942	439	7·981	0·900	0·	4·431	0·	Local Plumbago.
α 54	5×5×1	43429	43039	390	5·571	0·628	0·	0·795	11·0	Local pitted.
α 55	5×5×25	11380	10953	427	7·763	0·875	0·	5·366	1·0	Local Plumbago.
α 56	5×5×1	43026	42598	428	6·114	0·689	3·274	0·	0·	Uniform P.
α 57	5×5×25	11025	10652	373	6·781	0·765	0·	8·175	0·	Uniform P.

Box α. No. 1. Class No. 5. The Standard Bar of Wrought Iron.

α 58	5×3×·875	23972	23582	390	8·863	1·000	0·	5·951	0.	Fibre exposed with metallic lustre.

Box α. No. 1. Class No. 6. Scotch Cast Iron. Chilled.

α 59	5×5×1	42042	41578	464	6·628	0·747	0·	2·606	0·	Uniform.
α 60	5×5×1	43034	42525	509	7·271	0·820	0·	3·806	0·	Local pitted.

Box α. No. 1. Class No. 7. Welsh Cast Iron. Chilled.

α 61	5×5×1	41538	41126	412	5·885	0·663	0·	3·339	0·	Uniform P.
α 62	5×5×1	43251	42619	632	9·028	1·018	0·	3·497	0·	Local pitted.

Box α. No. 1. Class No. 8. Staffordshire Cast Iron. Chilled.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
No. of Exp. and mark of Spec.	Dimensions of Specimen.	Weight of Specimen in Grains.	Weight of Specimen after 732 days' immersion.	Total loss by Corrosion in 732 days.	Loss of weight per square inch of Surface.	Loss of weight referred to Standard Bar.	Increment of Corrosion.	Decrement of Corrosion.	Weight of Water absorbed.	Character of Corrosion.
	in. in. in.									
α 63	5×5 ×1·	42395	42000	395	5·642	0·636	0·	4·207	0·	Local Plumb.
α 64	5×5 ×1·	43868	43381	487	6·957	0·784	0·	2·352	0·	Local pitted.
Box α. No. 1. Class No. 9. Irish Cast Iron. Chilled.										
α 65	5×5 ×1·	42296	41841	455	6·500	0·733	0·	3·624	0·	Uniform P.
α 66	5×5 ×1·	42288	41781	507	7·242	0·817	0·	2·872	0·	Local pitted.
Box α. No. 1. Class No. 10. Mixed Cast Irons.										
α 67	5×5 ×1·	42875	42540	335	4·785	0·539	0·	2·951	5·0	Uniform.
α 68	5×5 ×1·	41970	41534	436	6·228	0·702	0·	4·588	0·	Local Plumb.
α 69	5×5 ×1·	41140	40652	488	6·971	0·787	0·	2·725	0·	Uniform.
Box α. No. 1. Class No. 11. Cast Irons of Messrs. Fairbairn's and Hodgkin's Experiments.										
α 70	3×1·25×1·25	8926	8802	124	7·481	0·844	0·	7·445	0·	Uniform P.
α 71	4×1· ×1·	7332	7149	183	10·166	1·147	0·	4·176	0·	Uniform P.
α 72	4×1· ×1·	7061	6941	120	6·666	0·752	0·	5·931	0·	Uniform P.
α 73	4×1· ×1·	7733	7610	123	6·833	0·770	0·	4·388	0·	Uniform P.
α 74	4×1· ×1·	7301	7112	189	10·500	1·184	0·	2·949	0·	Local Plumb.
α 75	4×1· ×1·	7826	7670	156	8·666	0·977	0·	2·859	0·	Local Plumb.
α 76	4×1· ×1·	7215	7117	98	5·444	0·614	0·	5·732	0·	Uniform.
Box α. No. 1. Class No. 12. Gray Cast Iron. Skin removed by Planing.										
α 77	5×5· × ·75	33595	32979	616	9·477	1·069	0·	10·556	0·	Uniform Plumb.

Second Course of Experiments.

TABLE III.—Box β. No. 2. containing Specimens of Cast and Wrought Iron immersed in foul Sea Water.

Sunk and moored a second time in the Foul Sea Water close to the mouth of the Great Kingstown main sewer, on a bottom of soft, putrid mud, on the 13th January, 1840, at one o'clock P.M. Weighed again and removed January 14, 1842, at same hour. Immersed 732 days.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
No. of Exp. and mark of Spec.	Dimensions of Specimen.	Weight of Specimen in Grains.	Weight of Specimen after 732 days' immersion.	Total loss by Corrosion in 732 days.	Loss per square inch of Surface.	Loss referred to Standard Bar.	Increment of Corrosion.	Decrement of Corrosion.	Weight of Water absorbed.	Character of Corrosion.
Box β. No. 2. Class No. 1. Scotch Cast Irons.										
	in. in. in.									
β 1	5×5×1	42674	42164	510	7·285	0·821	0·701	0·	0·	Uniform.
β 2	5×5×1	43046	42326	720	10·285	1·160	0·	2·983	0·	Local Plumb. deep.
Box β. No. 2. Class No. 2. Welsh Cast Iron.										
β 3	5×5×1	42160	41930	230	3·285	0·370	0·	0·394	0·	Uniform.
β 4	5×5×1	43032	42300	732	10·457	1·179	0·	3·893	0·	Local Plumb. deep.
Box β. No. 2. Class No. 3. Staffordshire Cast Iron.										
β 5	5×5×1	42237	41700	537	7·671	0·842	3·978	0·	0·	Local Plumbago.
β 6	5×5×1	43596	43527	69	0·985	0·111	0·	1·670	0·	Uniform.
Box β. No. 2. Class No. 4. Irish Cast Iron.										
β 7	5×5×1	41985	41442	543	7·757	0·875	2·361	0·	0·	Uniform.
β 8	5×5×1	42357	41938	419	5·985	0·675	0·	8·236	0·	Local Plumbago.
Box β. No. 2. Class No. 5. Mixed or alloyed Cast Iron.										
β 9	5×5×1	43051	42811	240	3·428	0·386	0·	1·218	0·	Local pitted.
β 10	5×5×1	42051	41255	796	11·085	1·250	3·280	0·	0·	Local pitted, deep.
β 11	5×5×1	42029	41548	481	6·871	0·775	0·982	0·	0·	Local pitted.
Box β. No. 2. Class No. 6. Standard Bar of Wrought Iron.										
β 12	4·875×3×·875	23436	22901	535	12·43	1·402	0·	6·000	0·	Uniform Fibrous.
Box β. No. 2. Class No. 7. Gray Cast Iron. Skin removed by Planing.										
β 13	5×5·×75	33150	31554	1596	24·55	2·769	0·	0·580	0·	Uniform Plumb.

TABLE II.—Wrought Iron and Steel Series.

Supplementary Box α′. No. 1.

Sunk along with Box No. 1. in Clear Sea Water, Kingstown Harbour, January 11, 1840, left to right, going from observer outwards; and upwards in same order.) Weighed

Observations of column 3rd:—T C. Tabular-crystalline. C C. Coarse-crystalline. F. Fibrous.

Supplementary Box α′. No. 1. Class

1. No. of Exp. and mark of Spec.	2. Commercial character, &c.	3. External character of Fracture.	4. How formed.	5. Specific grav. $S = \frac{Ws}{w}$.	6. Superficies of Specimen.	7. Weight of Specimen in Grains.	8. Weight of Specimen after 732 days' exposure.	9. Total loss by Corrosion in 732 days.
α′ 1	Finis[d] bar, For. of Dean, Glouc.	F	rolled	7·6795	9·619	4188	4091	97
α′ 2	Red short bar, Staffordshire....	F	rolled	7·6983	11·687	4736	4610	126
α′ 3	Cold short bar, Burchill's, Staff.	C	rolled	7·6514	11·151	5604	5456	148
α′ 4	Common bar, Shropshire, soft...	C	rolled	7·5870	21·50	7448	6671	777
α′ 5	Puddled bar, Cinderford.........	T C	rolled	7·5470	22·25	9883	9695	188
α′ 6	Common boiler plate, Banks ...	C C	rolled	7·6631	38·00	11388	10985	403
α′ 7	Best English bar, Bradley	F	rolled	7·7195	22·00	7763	7492	271
α′ 8	Finished Welsh bar, Doulais....	F	rolled	7·6550	26·50	13744	13457	287
α′ 9	Finished Welsh bar, Doulais....	F	rolled	7·5909	25·28	11983	11759	224
α′ 10	Puddled Welsh bar, Doulais....	C C	rolled	7·5385	23·25	10022	9742	280
α′ 11	Puddled Welsh bar, Doulais....	C C	rolled	7·6493	26·25	11200	10968	232
α′ 12	Damasked bar iron, Birmingham	F	hamm[d]	7·7917	11·88	2578	2428	150
α′ 13	Low Moor boiled plate.........	F	rolled	7·7556	38·00	11775	11455	320
α′ 14	Faggotted scrap iron bar	F & C	hamm[d]	7·7562	22·57	8251	8194	57
α′ 15	Swedish bar, Dannemora.......	F C	rolled	7·8204	22·00	8004	7766	238
α′ 16	Bar iron of Roscoe's cast steel...	F	hamm[d]	7·5839	21·50	7670	7417	253
α′ 17	Com. bar, Shrops., case hardened	F	rolled	7·6533	22·00	7814	7591	223
α′ 18	Blister steel, Roscoe's, soft......	F C	hamm[d]	7·8461	21·50	8306	8054	252
α′ 19	Shear steel, Roscoe's, soft.......	F C	hamm[d]	7·7395	21·00	7756	7492	264
α′ 20	Cast steel in ingot, Roscoe......	C	cast	7·4413	22·50	10652	10362	290
α′ 21	Spring steel, Bradley's, soft.....	F C	rolled	7·8076	27·50	5904	5616	288
α′ 22	Spring steel, Bradley's, temper[d]	F C	rolled	7·7809	28·45	6272	5936	336
α′ 23	Cast steel, hard as poss., Roscoe	F C	hamm[d]	7·6798	21·75	7605	7401	204
α′ 24	Cast steel, tilted, soft, Roscoe	F C	hamm[d]	7·7983	21·75	7626	7335	291

Box α′. No. 1. Class 14. Zinked

α′ 25	Zinked iron $\frac{3}{4}$-in. bolt............	F	hamm[d]	7·5830	7·83	2386	2356	30
α′ 26	Cast iron coated with zinc paint.......................	C C gray	cast	7·1380	70·00	43296	43128	168

First Course of Experiments. First immersion.

Wrought Iron, Steel, and Zinked Iron.

at one o'clock P.M. (The lid of box draws off to the right of observed; numbers read from and removed with Box α. No. 1, January 12, 1842; hence immersed 732 days.

F & C. Fibrous and Crystalline. F C. Fine Crystalline. C. Crystalline, *i. e.* mean size.

No. 13. Wrought Iron and Steel.

10.	11.	12.	13.	14.
Loss of Weight per square inch of Surface.	Loss of Weight referred to Standard Bar.	Weight of Water absorbed.	Character of Corrosion.	Hot or Cold Blast.
10·08	1·137	0·	Skin at the sides sound, ends fibrous	Hot
10·78	1·216	0·	Fibrous at sides and ends	Hot
13·27	1·497	0·	Fibrous at sides and ends, principally at sides	Hot
36·13	4·764	0·	Straight fibre uniformly exposed, lustre silvery	Cold
8·45	0·953	0·	Fibre everywhere exposed, small patches of skin sound	Cold
10·60	1·195	0·	Fine distinct lamina, perpendicular to sides, ends and edges smooth.	Hot
12·31	1·388	0·	Fibre straight, uniformly exposed	Hot
10·83	1·221	0·	Fibre equally exposed all over	Cold
8·85	0·998	0·	Fibre visible all over, but skin sound on edges	Hot
12·04	1·358	0·	Fibre not very apparent, tangled	Hot
8·83	0·996	0·	Fibre exposed at ends, skin sound on sides, action local	Cold
12·62	1·423	0·	Fibre uniformly and beautifully developed	Cold
8·40	0·947	0·	Edges lamellar, sides smooth and uniformly corroded	Cold
2·52	0·284	0·	Fibre developed at ends and edges, corrosion local	„
10·82	1·220	0·	Corrosion nearly confined to the ends, reduced to fibrous brushes.	Cold
11·72	1·322	0·	Fibre visible, corrosion nearly uniform	„
10·01	1·129	0·	Fibre visible, corrosion nearly uniform	Cold
11·67	1·316	0·	Fibre developed, subcrystalline, corrosion nearly uniform	„
12·27	1·384	0·	Corrosion nearly uniform, smooth, no fibrous structure visible	„
12·88	1·453	0·	Crystalline structure developed, plumbago of a silvery lustre	„
10·11	1·140	0·	Fibre scarcely visible, corrosion uniform	„
11·77	1·328	0·	Without fibre, smooth, locally pitted	„
9·37	1·057	0·	Without fibre, smooth, nearly uniform	„
13·38	1·569	0·	Fibre scarcely visible, corrosion nearly uniform	„

Cast and Wrought Iron.

3·83	0·432	0·0	Corroded at the ends slightly, zinking, black, brittle, and easily detached.	as α 77 Hot
2·40	0·270	4·0	Paint still visible, but reduced to oxides of zinc and iron, skin of metal sound	

TABLE IV.—Wrought Iron Series.

Box β. No. 2. Class 8.

1.	2.	3.	4.	5.	6.	7.	8.	9.
No. of Exp. and mark of Spec.	Commercial character of Iron, &c.	External character of Fracture.	How formed.	Specific gravity $S = \frac{W s}{w}$.	Superficies of Specimen.	Weight of Specimen in Grains.	Weight of Spec. after 732 days' exposure.	Total loss by Corrosion in 732 days.
β 15	Finis[d] bar, For. of Dean, Glouc.	F	rolled	7·6795	9·62	4181	3967	214
β 16	Red short bar, Staffordshire ...	F	rolled	7·6983	11·69	4758	4465	293
β 17	Cold short bar, Burchill.........	C	rolled	7·6514	11·15	5560	5342	218
β 18	Common bar, Shropshire, soft .	C	rolled	7·5870	21·50	7191	6827	364
β 19	Puddled bar, Cinderford.........	T C	rolled	7·5470	22·25	9164	8645	519
β 20	Common boiled plate, Banks...	C C	rolled	7·6631	38·00	11309	10484	825
β 21	Best English bar, Bradley	F	rolled	7·7195	22·00	7772	7409	363
β 22	Finished Welsh bar, Doulais ...	F	rolled	7·6550	26·50	13902	13243	659
β 23	Finished Welsh bar, Doulais ...	F	rolled	7·5909	24·68	11736	11248	488
β 24	Puddled Welsh bar, Doulais ...	C C	rolled	7·5385	23·25	10047	9591	456
β 25	Puddled Welsh bar, Doulais ...	C C	rolled	7·6493	26·25	11115	10635	480
β 26	Damasked iron, Birmingham...	F	hamm[d]	7·7917	11·88	2649	2332	317
β 27	Low Moor, boiler plate	F	rolled	7·7556	38·00	11992	11392	600
β 28	Faggotted scrap iron bar	F & C	hamm[d]	7·7562	22·57	8206	7872	334
β 29	Swedish iron, Dannemora	F C	rolled	7·8204	22·31	7961	7330	631
β 30	Bar iron of Roscoe's steel	F	hamm[d]	7·5839	21·50	7467	6950	517
β 31	Com. bar, Shrops., case harden[d]	F	rolled	7·6533	22·00	7818	7118	700
β 32	Blister steel, Roscoe	F C	hamm[d]	7·8461	21·50	8331	7973	358
β 33	Shear steel, Roscoe...............	F C	hamm[d]	7·7395	21·50	7621	7052	569
β 34	Cast steel in ingot, Roscoe......	C	cast	7·4413	22·50	10838	10508	330
β 35	Spring steel, soft, Bradley	F C	rolled	7·8076	27·50	5918	5512	406
β 36	Spring steel, tempered	F C	rolled	7·7809	28·05	6238	5686	552
β 37	Cast steel, hard as poss., Roscoe	F C	hamm[d]	7·6798	21·50	7911	7549	362
β 38	Cast steel, tilted, Roscoe	F C	hamm[d]	7·7983	23·00	7794	7293	501
	Box β. No. 2. Class No. 9. Zinked							
β 39	Zinked wrought iron bolt	fibrous	hamm[d]	7·5830	7·83	2483	2416	67
β 40	Cast iron coated with zinc paint	bright grey	cast	7·1380	38·45	21790	21673	117

Box β. No. 2. First immersion.

Wrought Iron and Steel.

10. Loss of Weight per square inch of Surface.	11. Loss of Weight referred to Standard Bar.	12. Weight of Water absorbed.	13. Character of Corrosion.	14. Hot or Cold Blast.
22·25	2·510	0·	Fibre straight, developed all over, most at the ends	Hot
25·06	2·827	0·	Fibre straight, developed all over, most at the ends	Hot
19·55	2·205	0·	Fibre straight, developed all over, most at the ends	Hot
16·93	1·910	0·	Fibre straight, developed uniformly all over	Cold
23·33	2·632	0·	Fibre tangled, corrosion local and pitted	Cold
21·58	2·436	0·	Sides smooth, slightly pitted, edges and ends lamellar	Hot
16·50	1·861	0·	Fibre straight, developed all over, but unequally	Hot
24·87	2·806	0·	Fibre finely developed, corrosion nearly uniform at ends and sides	Cold
19·77	2·230	0·	Fibre straight, corrosion nearly uniform, most at ends	Hot
19·61	2·212	0·	Fibre tangled, corrosion principally at the edges, local and pitted	Hot
18·29	2·063	0·	Fibre badly developed, corrosion chiefly at the edges, local and pitted.	Cold
26·68	3·010	0·	Fibre straight, deeply and beautifully developed.	Cold
15·76	1·778	0·	Lamellar on the edges, sides smooth, corrosion local and in pits	Cold
14·79	1·668	0·	Fibre developed at the ends, sides and edges smooth, corrosion local.	"
28·28	3·190	0·	Fibre developed at edges and ends, very deep at one end, corrosion local	Cold
24·05	2·713	0·	Fibre straight, strongly developed, corrosion local and pitted	"
31·82	3·590	0·	Fibre developed uniformly all over	Cold
16·65	1·878	0·	Fibre developed at ends only, corrosion uniform at sides and edges.	"
26·46	2·985	0·	Corrosion nearly uniform, metal locally removed in mammillary pits, fibre or spicula at ends	"
14·67	1·655	0·	Corrosion uniform, crystalline structure developed (crystals crossing at angles of 60° and 120°), silvery plumbago	"
14·76	1·665	0·	Fibre uniformly developed, edges lamellar	"
19·68	2·220	0·	Fibre uniformly developed, edges lamellar, corrosion slightly local	"
16·84	1·900	0·	Corrosion almost uniform, no fibre developed	"
21·78	2·457	0·	Fibre straight, imperfectly developed, corrosion local in mammillary pits.	"

Cast and Wrought Iron. First immersion.

8·55	9·65	0·0	Fibre visible at ends, sides smooth, zinking, black, brittle and easily detached.	as α 77 hot.
3·04	3·44	9·0	Paint still discernible, as a coat of mixed oxides of zinc and iron, pitted in some spots	

TABLE VI.—Wrought Iron Series.

Box δ. No. 4. Class No. 8.

1.	2.	3.	4.	5.	6.	7.	8.	9.
No. of Exp. and mark of Spec.	Commercial character of Iron, &c.	External character of Fracture.	How formed.	Specific gravity $S = \frac{W s}{w}$.	Superficies of Specimen.	Weight of Specimen in Grains.	Weight of Spec. after 732 days' exposure.	Total loss by Corrosion in 732 days.
δ 15	Finished bar, Forest of Dean...	F	rolled	7·6795	9·62	4150	3939	211
δ 16	Red short bar, Staffordshire ...	F	rolled	7·6983	11·51	4746	4535	211
δ 17	Cold short bar, Burchill.........	C	rolled	7·6514	11·15	5620	5331	289
δ 18	Common bar, Shropshire, soft	C	rolled	7·5870	21·50	7207	6718	489
δ 19	Puddled bar, Cinderford.........	T C	rolled	7·5470	19·19	8655	8445	210
δ 20	Common boiler plate, Banks ...	T C	rolled	7·6631	38·00	11126	10639	487
δ 21	Best English bar, Bradley	F	rolled	7·7195	22·57	7761	7421	340
δ 22	Finished Welsh bar, Doulais ...	F	rolled	7·6550	26·50	13933	13618	315
δ 23	Finished Welsh bar, Doulais ...	F	rolled	7·5909	25·28	11906	11577	329
δ 24	Puddled Welsh bar, Doulais ...	C C	rolled	7·5385	23·25	10187	9869	318
δ 25	Puddled Welsh bar, Doulais ...	C C	rolled	7·6493	25·50	10858	10501	357
δ 26	Damasked iron, Birmingham...	F	hamm[d]	7·7917	12·89	2771	2521	250
δ 27	Low Moor boiler plate	F	rolled	7·7556	38·00	11459	11080	379
δ 28	Faggotted scrap iron bar.........	F & C	hamm[d]	7·7562	22·57	8087	7697	390
δ 29	Swedish iron, Dannemora	F C	rolled	7·8204	22·32	7817	7643	174
δ 30	Bar iron of Roscoe's steel	F	hamm[d]	7·5839	22·49	7307	6958	349
δ 31	Com. bar, Shrops., case hardened	F	rolled	7·6533	22·00	7713	7541	172
δ 32	Blister steel, Roscoe	F C	hamm[d]	7·8461	22·32	8271	8073	198
δ 33	Shear steel, Roscoe...............	F C	hamm[d]	7·7395	21·50	7686	7402	284
δ 34	Cast steel in ingot, Roscoe......	C	cast	7·4413	22·50	10934	10625	309
δ 35	Spring steel, soft, Bradley......	F C	rolled	7·8706	28·04	5963	5659	304
δ 36	Spring steel, tempered, Bradley	F C	rolled	7·7809	28·99	6246	5869	377
δ 37	Cast steel, hard as poss., Roscoe	F C	hamm[d]	7·6798	21·75	7959	7715	244
δ 38	Cast steel, tilted, Roscoe	F C	hamm[d]	7·7983	22·50	7918	7680	238

Box δ. No. 4. Class No. 9. Zinked

δ 39	Zinked iron bolt.....................	F	hamm[d]	7·5830	7·83	2422	2391	31
δ 40	Cast iron coated with zinc paint	C C gray	cast	7·1380	38·45	19507	19559	...

* Weight increased by oxidation of the zinc,

Box δ. No. 4. First immersion.

Wrought Iron and Steel.

10.	11.	12.	13.	14.
Loss of Weight per square inch of Surface.	Loss of Weight referred to Standard Bar.	Weight of Water absorbed.	Character of Corrosion.	Hot or Cold Blast.
21·93	2·474	0·	Very locally and deeply acted on, fibre developed at the ends	Hot
18·33	2·068	0·	Very locally and deeply acted on, fibre developed at the ends	Hot
25·92	2·924	0·	Very locally and deeply acted on, fibre developed at the ends	Hot
22·75	2·566	0·	Fibre straight, corrosion uniform	Cold
10·94	1·234	0·	Fibre tangled, indistinct, corrosion uniform	Cold
12·82	1·446	0·	Lamellar on the edges, sides slightly pitted, corrosion local	Hot
15·07	1·700	0·	Fibre straight, corrosion nearly uniform	Hot
11·89	1·341	0·	Fibre straight, corrosion nearly uniform	Cold
13·02	1·469	0·	Fibre straight, corrosion nearly uniform, ends more acted on	Hot
13·68	1·543	0·	Fibre tangled, indistinct, corrosion local	Hot
14·00	1·579	0·	Fibre tangled, corrosion local and pitted, a few spicular crystals project from the edges	Cold
19·39	2·187	0·	Fibre straight, deeply and beautifully developed, lustre silvery	Cold
9·97	1·124	0·	Lamellar on the edges, corrosion somewhat local, and pitted	Cold
17·28	1·949	0·	Fibre straight, locally developed, corrosion most at the ends	,,
7·79	0·878	0·	Locally pitted, no fibre developed, except at the ends	Cold
15·52	1·751	0·	Fibre wavy, strongly developed, much corroded locally at both ends .	,,
7·82	0·882	0·	Fibre straight, uniform corrosion	Cold
8·87	1·001	0·	Fibre indistinct, smooth uniform corrosion, sub-cryst. struct. visible .	,,
13·21	1·490	0·	Corrosion uniform, smooth, no fibre visible, mammillary pits on sides and ends	,,
17·73	2·000	0·	Corrosion uniform, crystal. structure developed, with silv. plumbago .	,,
10·82	1·220	0·	Corrosion local, pitted on sides, lamellar edges and ends	,,
13·01	1·467	0·	Corrosion local, pitted on sides, fibre straight, and developed most at ends and edges	,,
11·22	1·265	0·	Corrosion uniform, smooth, no fibre developed	,,
10·58	1·193	0·	Corrosion uniform, smooth, no fibre devel., local pitting at one end .	,,

Cast and Wrought Iron. First immersion.

3·96	4·47	0·0	Fibre or spicula at both ends, sides smooth, zinc black and brittle, easily detached, surface beneath bright.	as a 77 hot.
...	...	5·0 *	Surface covered with a crust of oxides of zinc and iron, bluish-white colour, corroded beneath in spots.	

and also that of the iron in part.

Second Course of Experiments.

TABLE V.—Box δ. No. 4. containing Specimens of Cast and Wrought Iron, &c. immersed in foul River Water.

Sunk and moored a second time, in mid-stream of the river Liffey at Dublin, opposite the junction of the Poddle river therewith, on the 13th day of January, 1840, at one o'clock P.M., on a bottom of putrid mud. Weighed again and removed, January 14, 1842, at same hour. Immersed 732 days.

Box δ. No. 4. Class No. 1. Scotch Cast Iron.

1. No. of Exp. and mark of Spec.	2. Dimensions of Specimen.	3. Weight of Specimen in Grains.	4. Weight of Specimen after 732 days' immersion.	5. Total loss by Corrosion in 732 days.	6. Loss of weight per square inch of Surface.	7. Loss of weight referred to Standard Bar.	8. Increment of Corrosion.	9. Decrement of Corrosion.	10. Weight of Water absorbed.	11. Character of Corrosion.
	in. in. in.									
δ 1	5×5×1	41145	40894	251	3·585	0·404	0·	2·465	0·	Uniform.
δ 2	5×5×1	42885	42626	259	3·700	0·417	0·	3·915	0·	Local Plumb. deep.
Box δ. No. 4. Class No. 2. Welsh Cast Iron.										
δ 3	5×5×1	42181	42025	156	2·228	0·251	0·	2·845	0.	Uniform.
δ 4	5×5×1	42903	42690	213	3·042	0·343	0·	4·547	0·	Uniform Plumbago.
Box δ. No. 4. Class No. 3. Staffordshire Cast Iron.										
δ 5	5×5×1	44857	44703	154	2·200	0·343	0·	0·549	0·	Pitted.
δ 6	5×5×1	43478	43345	133	1·900	0·214	0·	3·036	0·	Pitted.
Box δ. No. 4. Class No. 4. Irish Cast Iron.										
δ 7	5×5×1	40305	40095	210	3·000	0·338	0·	4·661	0·	Uniform.
δ 8	5×5×1	42241	42033	208	2·857	0·321	0·	4·706	0·	Uniform.
Box δ. No. 4. Class No. 5. Mixed or alloyed Cast Iron.										
δ 9	5×5×1	44473	44296	177	2·528	0·285	0·	3·328	0·	Uniform.
δ 10	5×5×1	42147	41919	228	3·257	0·367	0·	2·676	0·	Uniform Plumb.
δ 11	5×5×1	91981	41809	172	2·457	0·277	0·	3·525	0·	Pitted.
Box δ. No. 4. Class No. 6. Standard Bar of Wrought Iron.										
δ 12	5×3×·875	24026	23781	245	5·568	0·635	0·	4·314	0·	Sides smooth, ends fibrous, straight, silvery lustre.
Box δ. No. 4. Class No. 7. Gray Cast Iron. Skin removed by Planing.										
δ 13	5×5×·75	33674	33169	505	7·769	0·876	0·	2·707	0·	Uniform Plumb.

Second Course of Experiments.

TABLE VII.—Box ε. No. 5, containing Specimens of Cast and Wrought Iron immersed in clear fresh River Water.

Sunk and moored in the clear, unpolluted water of the River Liffey, above the Tidal Limits, at the Royal Military Hospital, Kilmainham, on the 13th of January, 1840, at one o'clock P.M. Weighed again and removed on the 14th of January, 1842; hence immersed 732 days.

Box ε. No. 5. Class No. 1. Scotch Cast Iron.

1. No. of Exp. and mark of Spec.	2. Dimensions of Specimen.	3. Weight of Specimen in Grains.	4. Weight of Specimen after 732 days' immersion.	5. Total Loss by Corr. in 732 days.	6. Loss of Weight per square inch of Surface.	7. Loss of Weight referred to Standard Bar.	8. Increment on Corrosion.	9. Decrement on Corrosion.	10. Weight of Water absorbed.	11. Character of Corrosion.
	in. in. in.									
ε 1	5 × 5 × 1	42940	42854	86	1·228	0·138	0·	0·131	0·	Uniform.
ε 2	5 × 5 × 1	43493	43415	78	1·114	0·125	0·	0·641	0·	Pitted.
Box ε. No. 5. Class No. 2. Welsh Cast Iron.										
ε 3	5 × 5 × 1	42485	42430	55	0·785	0·088	0·	0·692	0·	Uniform.
ε 4	5 × 5 × 1	42923	42847	76	1·085	0·122	0·	0·886	0·	Pitted.
Box ε. No. 5. Class No. 3. Staffordshire Cast Iron.										
ε 5	5 × 5 × 1	43457	43386	71	1·014	0·114	0·	0·573	0·	Pitted.
ε 6	5 × 5 × 1	44095	44050	45	0·642	0·072	0·	0·796	0·	Pitted.
Box ε. No. 5. Class No. 4. Irish Cast Iron.										
ε 7	5 × 5 × 1	43024	42935	89	1·271	0·143	0·	0·409	0·	Pitted.
ε 8	5 × 5 × 1	43835	43768	67	0·957	0·107	0·	1·322	0·	Pitted.
Box ε. No. 5. Class No 5. Mixed or alloyed Cast Irons.										
ε 9	5 × 5 × 1	44125	44060	65	0·928	0·104	0·	0·647	0·	Pitted.
ε 10	5 × 5 × 1	43581	43525	56	0·800	0·090	0·	0·394	0·	Pitted.
ε 11	5 × 5 × 1	42975	42907	68	0·971	0·109	0·	0·705	0·	Pitted Plumb.
Box ε. No. 5. Class No. 6. Standard Bar of Wrought Iron.										
ε 12	51375 × 3 × 875	24426	24334	92	2·041	0·230	0·	0·225	0·	Fibre locally developed most on the ends.
Box ε. No. 5. Class No. 7. Gray Cast Iron. Skin removed by Planing.										
ε 13	5 × 5 × 75	33922	33846	76	1·169	0·131	0·	1·942	0·	Uniform P.

TABLE VIII.—Wrought Iron Series.

Box ε. No. 5. Class No. 8.

1.	2.	3.	4.	5.	6.	7.	8.	9.
No. of Exp. and mark of Spec.	Commercial character of Iron, &c.	External character of Fracture.	How formed.	Specific gravity $S = \frac{W s}{w}$.	Superficies of Specimen.	Weight of Specimen in Grains.	Weight of Specimen after 732 days' exposure.	Total loss by Corrosion in 732 days.
ε 15	Finished bar, Forest of Dean...	F	rolled	7·6795	9·62	4161	4146	15
ε 16	Red short bar, Staffordshire....	F	rolled	7·6983	11·69	4734	4719	15
ε 17	Cold short bar, Burchill.........	C	rolled	7·6514	10·96	5601	5585	16
ε 18	Common bar, Shropshire, soft	C	rolled	7·5870	21·50	7184	7146	38
ε 19	Puddled bar, Cinderford.........	T C	rolled	7·5470	20·13	8366	8339	27
ε 20	Common boiler plate, Banks ...	C C	rolled	7·6631	38·00	11499	11442	57
ε 21	Best English bar, Bradley	F	rolled	7·7195	22·57	7750	7715	35
ε 22	Finished Welsh bar, Doulais ...	F	rolled	7·6550	26·50	13607	13570	37
ε 23	Finished Welsh bar, Doulais ...	F	rolled	7·5909	23·96	11609	11585	24
ε 24	Puddled Welsh bar, Doulais ...	C C	rolled	7·5385	23·25	9833	9814	19
ε 25	Puddled Welsh bar, Doulais ...	C C	rolled	7·6493	26·25	11166	11145	21
ε 26	Damasked iron, Birmingham...	F	hamm[d]	7·7917	12·89	2710	2690	20
ε 27	Low Moor boiler plate	F	rolled	7·7556	38·00	11776	11723	53
ε 28	Faggotted scrap iron bar.........	F & C	hamm[d]	7·7562	22·57	8047	8025	22
ε 29	Swedish iron, Dannemora	F C	rolled	7·8204	22·89	8256	8229	27
ε 30	Bar iron of Roscoe's steel	F	hamm[d]	7·5839	21·50	7045	7023	22
ε 31	Com. Shrops. bar, case hardened	F	rolled	7·6533	22·00	7393	7371	22
ε 32	Blister steel, Roscoe	F C	hamm[d]	7·8461	23·29	8249	8235	14
ε 33	Shear steel, Roscoe...............	F C	hamm[d]	7·7395	21·75	7711	7689	22
ε 34	Cast steel in ingot, Roscoe......	C	cast	7·4413	22·50	11246	11212	34
ε 35	Spring steel, soft, Bradley	F C	rolled	7·8076	27·50	5958	5929	29
ε 36	Spring steel, tempered, Bradley	F C	rolled	7·7809	28·04	6180	6117	63
ε 37	Cast steel, hard as poss., Roscoe	F C	hamm[d]	7·6798	21·50	7940	7903	37
ε 38	Cast steel, tilted, Roscoe	F C	hamm[d]	7·7983	21·50	8180	8158	22

Box ε. No. 5. Class No 9. Zinked

ε 39	Zinked iron bolt	F	hamm[d]	7·5830	7·83	2361	2357	4
ε 40	Cast iron coated with zinc paint........................	C C gray	cast	7·1380	39·21	20837	20899	...

* Weight increased by oxidation

Box ε. No. 5. First immersion.

Wrought Iron and Steel.

10. Loss of Weight per square inch of Surface.	11. Loss of Weight referred to Standard Bar.	12. Weight of Water absorbed.	13. Character of Corrosion.	14. Hot or Cold Blast.
1·559	0·175	0·	Corrosion uniform, no fibre visible	Hot
1·283	0·144	0·	Corrosion uniform, no fibre visible	Hot
1·459	0·164	0·	Corrosion uniform, no fibre visible	Hot
1·768	0·199	0·	Corrosion uniform, fibre indistinctly developed	Cold
1·341	0·051	0·	Corrosion uniform, no fibre developed	Cold
1·500	0·169	0·	Lamellar structure just visible at ends, sides and edges smooth, corrosion uniform	Hot
1·551	0·174	0·	Corrosion uniform, fibre indistinctly developed on sides and ends.	Hot
1·396	0·157	0·	Corrosion uniform, fibre indistinctly visible	Cold
1·002	0·133	0·	Corrosion uniform, fibre indistinctly visible	Hot
0·817	0·092	0·	Corrosion uniform, no fibre visible	Hot
0·802	0·090	0·	Corrosion uniform, fibre tangled, just visible at the ends	Cold
1·552	0·175	0·	Corrosion uniform, no fibre visible	Cold
1·395	0·157	0·	Corrosion uniform, edges lamellar, sides smooth	Cold
0·964	0·108	0·	Corrosion uniform, no fibre visible	„
1·179	0·133	0·	Corrosion uniform, fibre just discernible at the ends	Cold
1·023	0·115	0·	Corrosion local, but slight, no fibre visible, forge scale still on in many places	„
1·000	0·112	0·	Corrosion uniform and smooth, fibre developed, *except* on the ends which were smooth	„
0·601	0·067	0·	Corrosion uniform, no fibre visible, except at the ends where just discernible	„
1·012	0·114	0·	Corrosion uniform, smooth, no fibre visible	„
1·511	0·170	0·	Corrosion nearly uniform, crystalline structure developed in spots.	„
1·055	0·119	0·	Fibre developed at the ends, sides smooth, but corroded in many small pits	„
2·248	0·253	0·	Corrosion uniform, smooth, fibre imperfectly discernible all over	„
1·721	0·194	0·	Corroded locally, but without development of fibre	„
1·023	0·115	0·	Corrosion uniform, smooth, no fibre developed	„

Cast and Wrought Iron. First immersion.

0·512	5·77	0·	Corrosion slight at the ends, sides, &c. smooth and black, zinc brittle and readily detached, surface beneath bright.	as *a* 77 hot.
...	...	6·0 *	Paint generally still sound, but gone in blotches where corrosion had taken place, zinc oxidized.	

of the zinc and iron.

First Course

TABLE IX.—Box ζ. No. 6. First Exposure, containing Specimens of Cast
Atmospheric Influences

Placed on the summit of an exposed Building of about 50 feet in height within the City of
the 21st of January, 1842;

Latitude of Dublin...... 52° 2′ 2″ N.
Longitude of Dublin ... 6° 15′ W.
Altitude above mean tide level, 105 feet.
Prevailing Winds,

1.	2.		3.	4.	5.	6.
No. of Exp. and mark of Spec.	Commercial character of Iron, &c.	Hot or Cold Blast.	External character of Fracture.	How Cast.	Specific Gravity of Specimen $S=\frac{Ws}{w}$.	Dimensions of Specimen.
						in. in. in.
	Box ζ. No. 6. Class No. 1.					
ζ 1	Calder, No. 1.	Hot	Dark gray	Green	7·027	5 × 5 × 1
ζ 2	Calder, No. 1.	Hot	Mottled	Chilled	7·079	5 × 5 × 1
	Box ζ. No. 6. Class No. 2.					
ζ 3	Pentwyn, No. 2.	Hot	Mottled	Green	7·017	5 × 5 × 1
ζ 4	Pentwyn, No. 2.	Hot	Silvery	Chilled	7·129	5 × 5 × 1
	Box ζ. No. 6. Class No. 3.					
ζ 5	Apedale, No. 2......................	Cold	Mottled	Green	7·268	5 × 5 × 1
ζ 6	Apedale, No. 2......................	Cold	Silvery	Chilled	7·603	5 × 5 × 1
	Box ζ. No. 6. Class No. 4.					
ζ 7	Arigna, No. 3.	Cold	Dull gray	Green	7·141	5 × 5 × 1
ζ 8	Arigna, No. 3.	Cold	Mottled	Chilled	7·308	5 × 5 × 1
	Box ζ. No 6. Class No. 5.					
ζ 9	Hardest procurable. Old fire-bars, &c.....................	...	Silvery crystals	Chilled	7·624	5 × 5 × 1
ζ 10	½ Calder, No. 1. .... + ½ Pentwyn, No. 2.	Hot Hot	Close dull gray	Green	6·978	5 × 5 × 1
ζ 11	½ Arigna, No. 2. .... + ½ Pentwyn, No. 2.	Cold Hot	Close dull gray	Green	7·050	5 × 5 × 1
	Box ζ. No. 6. Class No. 6.					
ζ 12	Doulais common bar, No. 2. ...	Hot	Fibrous	...	7·587	5×3×·875

of Experiments.

and Wrought Iron freely exposed to air and moisture under the ordinary at Dublin.

Dublin, and exposed on the 1st day of August 1840. Removed, cleaned and weighed on hence exposed for 539 days.

Annual Mean Temperature...... 50·24 Fahr.
Annual Mean Pressure .... 29·60 Inches.
Annual Mean fall of Rain ...... 27·33 ...
East and West, and South-West.

7.	8.	9.	10.	11.	12.	13.	14.
Weight of Specimen in Grains.	Weight of Specimen after 539 days' exposure.	Total loss by Corrosion in 539 days.	Loss of Weight per square inch of Surface.	Loss of Weight referred to Standard Bar.	Weight of Water absorbed.	Loss per square inch of Surface in 732 days.	Character of Corrosion.
Scotch Cast Iron.							
43149	42835	314	4·485	0·506	0·	6·128	Uniform minute pitting
43939	43720	219	3·128	0·352	0·	4·099	Uniform minute pitting
Welsh Cast Iron.							
42239	41885	354	5·057	0·570	0·	6·867	Uniform minute pitting
43239	43095	144	2·057	0·232	0·	2·793	Deeply pitted
Staffordshire Cast Iron.							
43735	43491	244	3·485	0·393	0·	4·732	Uniform
43562	43541	21	0·300	0·033	0·	0·407	Local pitted
Irish Cast Iron.							
41745	41435	310	4·428	0·499	0·	4·428	Uniform minute pitting
43465	43395	70	1·300	0·112	0·	1·357	Local pitted, slight
Mixed or alloyed Irons.							
43325	43181	144	2·057	0·232	0·	2·793	Local pitted, slight
42241	41898	343	4·900	0·552	0·	6·654	Uniform minute pitting
41341	41038	303	4·328	0·488	0·	5·877	Uniform minute pitting
Standard Bar of Wrought Iron.							
24274	24018	256	5·818	0·656	0· 0·	7·901	Minute pitting most at ends, fibre visible

Box ζ. No. 6. Class No. 7.

1. No. of Exp. and mark of Spec.	2. Commercial character of Iron, &c.	Hot or Cold Blast.	3. External Character of Fracture.	4. How Cast.	5. Specific Gravity of Specimen $S=\frac{Ws}{w}$.	6. Dimensions of Specimen. in. in. in.
ζ 13	$\frac{1}{3}$ Calder, No. 1. + $\frac{1}{3}$ Pentwyn, No. 2. + $\frac{1}{3}$ Scrap ...	Hot	Close bright gray	Green	7·138	5 × 5 × ·75

Box ζ. No. 6. Class No. 8.

ζ 14	$\frac{1}{3}$ Calder, No. 1. + $\frac{1}{2}$ Pentwyn, No. 2. + $\frac{1}{3}$ Scrap ...	Hot	Close bright gray	Green	7·168	5 × 5 × 1
ζ 15	$\frac{1}{3}$ Calder, No. 1. + $\frac{1}{3}$ Pentwyn, No. 2. + $\frac{1}{3}$ Scrap ...	Hot	Close bright gray	Green	7·168	5 × 5 × 1
ζ 16	$\frac{1}{3}$ Calder, No. 1. + $\frac{1}{3}$ Pentwyn, No. 2. + $\frac{1}{3}$ Scrap ...	Hot	Close bright gray	Green	7·168	5 × 5 × 1
ζ 17	$\frac{1}{3}$ Calder, No. 1. + Pentwyn, No. 2. + $\frac{1}{3}$ Scrap	Hot	Close bright gray	Green	7·168	5 × 5 × 1
ζ 18	$\frac{1}{3}$ Calder, No. 1. + Pentwyn, No. 2. + $\frac{1}{3}$ Scrap	Hot	Close bright gray	Green	7·168	5 × 5 × 1

Supplementary Table.

No. of Experiment and mark of Specimen.	Protective Paint or Varnish.	State of covering after 539 days' exposure.
ζ 14	Caoutchouc varnish	Caoutchouc not visible, surface rusty......
ζ 14	Best white lead paint	Paint destroyed in various blotches ......
ζ 15	Copal varnish	Varnish still, smooth and shining ....
ζ 15	Asphaltum varnish	Varnish still, smooth and shining ....
ζ 16	Mastic varnish	Varnish wholly invisible and gone.........
ζ 16	Swedish tar	Tar still visible, but white and hydrated.
ζ 17	Three parts wax + two parts tallow	Still visible and sound, but hydrated ....
ζ 17	Coal-tar, laid on hot.....................	Surface still black and shining, smooth...
ζ 18	Turpentine varnish	Turpentine hydrated and partly washed away ....
ζ 18	Drying oil	Surface still black and shining ....

Gray Cast Iron. Skin removed by Planing.

7.	8.	9.	10.	11.	12.	13.	14.
Weight of Specimen in Grains.	Weight of Specimen after 539 days' exposure.	Total loss by Corrosion in 539 days.	Loss of Weight per square inch of Surface.	Loss of Weight referred to Standard Bar.	Weight of Water absorbed.	Loss per square inch of Surface in 732 days.	Character of Corrosion.
33750	33294	456	7·015	0·791	0·	9·526	Uniform minute pitting

Gray Cast Iron, protected by Paints or Varnishes.

42594	42409	185	2·642	0·298	0·	3·588	
42644	42620	24	0·342	0·038	0·	0·464	
42399	42349	50	0·714	0·080	0·	1·969	
42007	41974	33	0·471	0·053	0·	0·639	
42004	41971	36	0·514	0·057	0·	0·707	

Box ζ. No. 6. Class No. 8.

Condition of surface of Specimen after 539 days' exposure.		Order of Protective Power.
Surface uniformly corroded..	....	9
Corroded locally in pits, where paint gone	....	10
Rusty spots, chiefly at the edges..	....	2
Rusty spots, chiefly at the edges..	....	1
Surface uniformly corroded..	....	8
Corroded locally in spots..	....	7
No corrosion visible..	....	3
A few rusty spots at the edges...	....	4
Corroded locally in spots..	....	6
A few rusty spots at the edges...	....	5

TABLE X.—Wrought Iron

Box ζ. No. 6. Class No. 9.

1.	2.		3.	4.	5.	6.	7.	8.
No. of Exp. and mark of Spec.	Commercial character of Iron, &c.		External character of Fracture.	How formed.	Specific grav. $S = \frac{Ws}{w}$	Superficies of Specimen.	Weight of Specimen in Grains.	Weight of Specimen after 539 days' exposure.
ζ 19	Finished bar, Forest of Dean......	Hot	F	rolled	7·6795	6·48	2095	2057
ζ 20	Red short bar, Staffordshire	Hot	F	rolled	7·6983	5·91	2083	2026
ζ 21	Cold short bar, Burchill............	Hot	C	rolled	7·6514	6·47	2480	2435
ζ 22	Common bar, Shropshire, soft ...	Cold	C	rolled	7·5870	21·50	7579	7246
ζ 23	Puddled bar, Cinderford............	Cold	T C	rolled	7·5470	...	...	...
ζ 24	Common boiler plate, Banks......	Hot	C C	rolled	7·6631	30·34	8796	8437
ζ 25	Best English bar, Bradley.........	Hot	F	rolled	7·7195	16·21	5242	5074
ζ 26	Finished Welsh bar, Doulais	Cold	F	rolled	7·6550	27·25	14174	13898
ζ 27	Finished Welsh bar, Doulais	Hot	F	rolled	7·5909	9·13	3425	3348
ζ 28	Puddled Welsh bar, Doulais	Hot	C C	rolled	7·5385	9·00	2646	2604
ζ 29	Puddled Welsh bar, Doulais	Cold	C C	rolled	7·6493	8·88	2402	2314
ζ 30	Damasked iron, Birmingham......	Cold	F	hamm[d]	7·7917	11·68	2442	2324
ζ 31	Low Moor boiler plate	Cold	F	rolled	7·7556	29·46	9177	8896
ζ 32	Faggotted scrap iron bar............	...	F & C	hamm[d]	7·7562	16·21	5654	5550
ζ 33	Swedish iron, Dannemora.........	Cold	F C	rolled	7·8204	16·21	5671	5452
ζ 34	Bar iron of Roscoe's steel	...	F	hamm[d]	7·5839	21·50	6983	6727
ζ 35	Com. bar, Shropshire, case hard.	Cold	F	rolled	7·6533	27·00	9124	9041
ζ 36	Blister steel, Roscoe	...	F C	hamm[d]	7·8461	12·50	4438	4326
ζ 37	Shear steel, Roscoe..................	...	F C	hamm[d]	7·7395	21·50	7729	7488
ζ 38	Cast steel in ingot, Roscoe.........	...	C	cast	7·4413	22·50	11403	11246
ζ 39	Spring steel, soft, Bradley.........	...	F C	rolled	7·8076	19·38	4072	3897
ζ 40	Spring steel, tempered, Bradley...	...	F C	rolled	7·7809	20·23	4304	4088
ζ 41	Cast steel, hard as poss., Roscoe	...	F C	hamm[d]	7·6798	21·50	7904	7807
ζ 42	Cast steel, tilted, Roscoe	...	F C	hamm[d]	7·7983	21·50	7687	7496

Box ζ. No. 6. Class No. 10.

ζ 43	Zinked iron ½-in. bolt...............	...	F	hamm[d]	7·5830	11·85	2674	2674
ζ 44	Cast iron coated with zinc paint............................	Hot	gray C C	cast	7·1380	70·00	43937	43982

* Slight tarnish. † Increase of

Series. Box ζ. No. 6.

Wrought Iron and Steel.

9. Total loss by Cor. in 539 days.	10. Loss of Weight per square inch of Surface.	11. Loss of Weight referred to Standard Bar.	12. Weight of Water absorbed.	13. Loss per square inch of Surface in 732 days.	14. Character of Corrosion.
58	8·95	1·009	0·	12·15	Uniform minute pitting, or *fine fret.*
57	9·65	1·088	0·	13·10	Uniform fine fret.
45	6·96	0·785	0·	9·45	Uniform fine fret.
333	15·49	0·748	0·	21·03	Nearly uniform fine fret, most at the ends.
...	...	...	...	...	No specimen.
359	11·83	1·334	0·	16·06	Uniform fine fret.
168	10·36	1·168	0·	14·07	Uniform fine fret.
276	10·13	1·142	0·	13·75	Uniform fine fret.
77	8·43	0·951	0·	11·44	Nearly uniform fret, some local pitting.
60	6·66	0·751	0·	9·11	Nearly uniform fret, some local pitting.
88	9·91	1·118	0·	13·45	Uniform fine fret, fibre discernible.
118	10·10	1·139	0·	13·71	Uniform fine fret.
281	9·54	1·076	0·	12·95	Uniform very fine fret.
104	6·37	0·718	0·	8·96	Uniform fine fret.
219	13·51	1·749	0·	18·34	Uniform coarse fret, approaching to local pitting.
256	11·91	1·343	0·	16·22	Uniform very fine fret.
83	3·07	0·346	0·	4·16	Uniform fine fret.
112	8·96	1·010	0·	12·16	Uniform coarse fret.
241	11·21	1·264	0·	15·22	Uniform very fine fret, the pitting mammillary.
157	6·98	0·787	0·	9·47	Uniform fine fret.
175	9·03	1·018	0·	12·26	Uniform fine fret.
216	10·67	1·203	0·	14·49	Uniform fine fret, pitted locally at one end.
97	4·51	0·508	0·	6·12	Uniform fine fret.
191	8·88	1·300	0·	12·5	Uniform fine fret.

Zinked Wrought and Cast Iron.

0·	0·	0·	0·*	0·	Surface smooth, free from rust where covered with zinc, which has a coppery tarnish, but iron rusty where bare.
...	...	...	0·†	0·	Paint sound and good generally, but beginning to rust through in blotches, and zinc to oxidize.

weight by oxidation of zinc and iron.

Table XI.—Wrought Iron Standard Bar, in presence of Zinc, Copper, and their Alloys, in Sea Water.

1.	2.	3.	4.	5.	6.	7.	8.	9.
No.	Atomic Constitution of Alloy.	Weight of piece previous to immersion.	Weight of piece after immersion for 1860 hours.	Total loss of Weight.	Weight of Wrought Iron previous to immersion.	Weight of Wrought Iron after immersion for 1860 hours.	Total loss of Weight.	Loss of Weight per square inch of Surface in 387 days.
1.	Cu	504·30	504·23	0·07	1008·21	1003·64	4·57	22·85
2.	Zn + 10 Cu	575·20	575·14	0·06	1008·21	1003·73	4·48	22·40
3.	Zn + 9 Cu	549·81	549·74	0·07	1008·21	1003·77	4·44	22·20
4.	Zn + 8 Cu	559·21	559·14	0·07	1008·21	1004·18	4·03	20·15
5.	Zn + 7 Cu	528·62	528·56	0·06	1008·21	1004·48	3·73	18·65
6.	Zn + 6 Cu	553·34	553·32	0·02	1008·21	1004·71	3·50	17·50
7.	Zn + 5 Cu	492·31	492·22	0·09	1008·21	1004·80	3·41	17·05
8.	Zn + 4 Cu	503·11	503·04	0·07	1008·21	1004·97	3·24	16·20
9.	Zn + 3 Cu	466·22	466·16	0·06	1008·21	1005·09	3·12	15·60
10.	Zn + 2 Cu	493·34	493·31	0·03	1008·21	1005·12	3·09	15·45
11.	Zn + Cu	488·97	487·13	0·04	1008·21	1005·21	3·00	15·00
12.	2 Zn + Cu	480·00	479·84	0·16	1008·21	1004·90	3·31	16·55
13.	3 Zn + Cu	424·42	422·29	2·13	1008·21	1005·11	3·10	15·50
14.	4 Zn + Cu	433·91	431·63	2·28	1008·21	1006·21	2·00	10·00
15.	5 Zn + Cu	414·10	410·93	3·17	1008·21	1008·21	0·00	0·00
16.	Zn............	420·75	417·24	3·51	1008·21	1008·21	0·00	0·00
17.	Fe	......	......	...	1008·21	1006·08	2·13	10·65

Table XII.—Wrought Iron Standard Bar, in presence of Tin and Copper, and their Alloys, in Sea Water.

1.	2.	3.	4.	5.	6.	7.	8.	9.
No.	Atomic Constitution of Alloy.	Weight of piece previous to immersion.	Weight of piece after immersion for 1860 hours.	Total loss of Weight.	Weight of Wrought Iron previous to immersion.	Weight of Iron after immersion for 1860 hours.	Total loss of Weight.	Loss of Weight persquare inch of Surface in 387 days.
1.	Cu	496·21	496·12	0·09	1009·30	1004·82	4·48	22·40
2.	Sn + 10 Cu	550·00	549·84	0·16	1009·30	1003·89	5·41	27·05
3.	Sn + 9 Cu	508·01	507·72	0·29	1009·30	1003·18	6·12	30·60
4.	Sn + 8 Cu	499·72	499·62	0·10	1009·30	1002·93	6·37	31·85
5.	Sn + 7 Cu	523·80	523·59	0·21	1009·30	1002·84	6·46	32·30
6.	Sn + 6 Cu	513·11	512·88	0·23	1009·30	1002·66	6·64	33·20
7.	Sn + 5 Cu	554·21	553·93	0·28	1009·30	1002·46	6·84	34·20
8.	Sn + 4 Cu	516·90	516·61	0·29	1009·30	1002·89	6·41	32·05
9.	Sn + 3 Cu	471·87	471·53	0·34	1009·30	1004·97	4·33	21·65
10.	Sn + 2 Cu	526·36	525·98	0·38	1009·30	1004·47	4·83	24·15
11.	Sn + Cu	476·91	475·50	0·41	1009·30	1003·62	5·67	28·35
12.	Sn + Cu	490·30	489·94	0·36	1009·30	1003·73	5·57	27·87
13.	Sn + Cu	451·48	451·24	0·24	1009·30	1004·96	4·34	21·70
14.	Sn + Cu	455·65	455·49	0·16	1009·30	1003·50	5·80	29·00
15.	Sn + Cu	446·17	446·08	0·09	1009·30	1003·17	6·13	30·65
16.	Sn	413·62	413·36	0·26	1009·30	1001·40	7·90	39·50
17.	Fe	......	......	...	1009·30	1007·07	2·23	11·15

Table XIII.

Showing the average Loss of all varieties, of Cast Iron, Wrought Iron and Steel experimented on, in each of the conditions of exposure, for a period of 732 Days, on one square inch of Surface.

No.	Denomination of Iron, &c.	α.	β.	δ.	ϵ.	ζ.	Observations.
1.	Chilled Cast Iron	7·056	6·228	2·806	0·945	2·030	The whole of the results of ζ are from the first exposure.
2.	Cast in Green Sand, Welsh Cast Iron	5·740	3·285	2·228	0·785	6·867	
3.	Cast in Green Sand, Irish Cast Iron	7·568	7·757	3·000	1·271	4·428	
4.	Cast in Green Sand, Staffordshire, Shropshire, and Gloucestershire	5·966	7·671	2·200	1·014	4·732	The results of α, β, δ, ϵ, from No. 1 to No. 8 inclusive, and No. 11, are from second immersion.
5.	Cast in Green Sand, Scotch Cast Iron	6·515	7·285	3·585	1·228	6·128	
6.	Cast in Green Sand, Fairbairn and Hodgkinson's	7·965					
7.	Cast in Green Sand, Skin removed by planing	9·477	24·550	7·769	1·169	9·526	
8.	Cast in Green Sand, Mixed Cast Iron	6·599	9·478	2·817	0·835	6·265	All the remainder are results from first immersion or exposure.
9.	Wrought Iron, average of all	11·71	20·90	15·37	1·310	13·38	
10.	Steel, average of all	10·35	20·75	12·09	1·250	11·35	
11.	Standard Bar of Wrought Iron	8·63	12·430	5·568	2·041	7·901	
12.	Cast Iron Surface protected, Zinked	3·83	8·55	3·96	0·512	0·000	
13.	Cast Iron Surface protected, Zinc Paint	2·40	3·04	0·00	0·000	0·000	
14.	Cast Iron Surface protected, protected by Paints and Varnishes	...	...	...	...	1·271	
15.	Cast Iron in contact with Brass (10, 11, 12, Table IX.)	20·35	...	...	...	...	
16.	Cast Iron in contact with Gun-metal (2, 3, 4, Table X.)	37·26	...	...	...	...	
17.	Cast Iron in contact with Copper	21·37	...	...	...	...	
18.	Wrought Iron (Standard Bar) in contact with Brass	29·64	...	...	...	...	
19.	Wrought Iron (Standard Bar) in contact with Gun-metal	56·39	...	...	...	...	
20.	Wrought Iron (Standard Bar) in contact with Copper	42·79	...	...	...	...	

TABLE XIV.—General comparison of preceding results of the Action of Air and Water, under five conditions of experiment, on various Specimens of Cast and Wrought Iron of one inch thick, all reduced to a common period of 732 days, being second immersion of Nos. 1 to 13 inclusive, and first immersion of the remainder.

			α.		β.		δ.		ε.		ζ.		Average.
No.	Denomination of Iron.	Commercial Number.	Loss per unit of Surface.	Index of Corrosion.	Loss per unit of Surface.	Index of Corrosion.	Loss per unit of Surface.	Index of Corrosion.	Loss per unit of Surface.	Index of Corrosion.	Loss per unit of Surface.	Index of Corrosion.	Loss in all Waters per square inch of Surface.
1.	Calder, hot	No. 1.	6·628	0·747	7·285	0·821	3·585	0·404	1·228	0·138	6·128	0·691	4·681
2.	Calder, hot, chilled	No. 1.	7·271	0·820	10·285	1·160	3·700	0·417	1·114	0·125	4·099	0·462	5·592
3.	Pentwyn, hot	No. 2.	5·885	0·663	3·285	0·370	2·228	0·251	0·785	0·088	6·867	0·774	3·045
4.	Pentwyn, hot, chilled	No. 2.	9·028	1·018	10·457	1·179	3·402	0·343	1·085	0·122	2·793	0·315	5·903
5.	Apedale, hot	No. 2.	5·642	0·636	7·671	0·842	2·200	0·343	1·014	0·114	4·732	0·533	4·131
6.	Apedale, hot, chilled	No. 2.	6·957	0·784	0·985	0·111	1·900	0·214	0·642	0·072	0·407	0·045	2·621
7.	Arigna, cold	No. 3.	6·500	0·733	7·757	0·875	3·000	0·338	1·271	0·143	4·428	0·499	4·632
8.	Arigna, cold, chilled	No. 3.	7·242	0·817	5·985	0·675	2·857	0·321	0·957	0·107	1·357	0·153	4·260
9.	Hardest procurable, chilled	...	4·785	0·539	3·428	0·386	2·528	0·285	0·928	0·104	2·793	0·315	2·917
10.	½ Calder, No. 1 + ½ Pentwyn, No. 2	...	6·228	0·702	11·085	1·250	3·257	0·367	0·800	0·090	6·654	0·750	5·342
11.	½ Arigna, No. 2 + ½ Pentwyn, No. 2	...	6·971	0·787	6·871	0·775	2·457	0·277	0·971	0·109	5·877	0·663	4·317
12.	Cast iron, skin removed by planing	...	9·477	1·069	24·550	2·769	7·769	0·876	1·169	0·131	9·526	1·074	10·741
13.	Wrought iron standard bar	...	8·863	1·000	12·430	1·402	5·568	0·635	2·041	0·230	7·901	0·891	7·225
14.	Red short bar, Staffordshire	...	10·78	1·216	25·06	2·510	18·33	2·068	1·283	0·144	13·10	1·478	13·863
15.	Common bar, Shropshire	...	36·13	4·764	16·93	1·910	22·75	2·566	1·768	0·199	21·03	2·372	19·344
16.	Best bar, Staffordshire	...	12·31	1·388	16·50	1·861	15·07	1·700	1·551	0·174	14·07	1·587	11·357
17.	Best Welsh bar, Doulais	...	10·83	1·221	24·87	2·806	11·89	1·341	1·396	0·157	13·75	1·551	12·246
18.	Low Moor boiler plate	...	8·40	0·947	15·76	1·778	9·97	1·124	1·395	0·157	12·95	1·461	8·881
19.	Common boiler plate, Banks	...	10·60	1·195	21·58	2·436	12·82	1·446	1·500	0·169	16·06	1·812	11·625
20.	Swedish bar, Dannemora	...	10·82	1·220	28·28	3·190	7·79	0·878	1·179	0·133	18·34	2·069	12·017
21.	Faggotted scrap bar	...	2·52	0·284	14·79	1·668	17·28	1·949	0·964	0·108	8·65	0·975	8·888
22.	Blister steel bar, soft	...	11·67	1·316	16·65	1·878	8·87	1·001	0·601	0·067	12·16	1·360	9·447
23.	Shear steel bar, soft	...	12·27	1·384	26·46	2·985	13·21	1·490	1·012	0·114	15·22	1·717	13·238
24.	Cast steel, tilted, soft	...	13·38	1·569	21·87	2·457	10·58	1·193	1·023	0·115	12·05	1·359	11·713
25.	Cast steel, tilted, hard	...	9·37	1·057	16·84	1·900	11·22	1·265	1·721	0·194	6·12	0·690	9·787

TABLE XV.—Of the average amount and depth of Corrosion in Clear Sea Water, in Foul Sea Water, in Clear Fresh Water, and freely exposed to the Atmosphere and Weather, of the various Wrought Irons and Steels experimented on, at the end of *one century*, upon one superficial foot of surface, deduced from the preceding results.

[This Table coordinates with Table VIII. of Second Report.]

		In Clear Sea Water.			In Foul Sea Water.			In Clear Fresh Water.			Exposed to the Weather in Dublin.		
	Class of Iron.	Average loss of Weight per superficial foot in 732 days.	Deduced average loss per superficial foot in one century.	Approximate depth of Corrosion in one century due to this amount of loss.	Average loss of Weight per superficial foot in 732 days.	Deduced average loss per superficial foot in one century.	Approximate depth of Corrosion in one century due to this amount of loss.	Average loss of Weight per superficial foot in 732 days.	Deduced average loss per superficial foot in one century.	Approximate depth of Corrosion in one century due to this amount of loss.	Average loss of Weight per superficial foot in 732 days.	Deduced average loss per superficial foot in one century.	Approximate depth of Corrosion in one century due to this amount of loss.
1.	Red short bar, Staffordshire.	1552·32	11·06	0·276	3608·64	25·74	0·644	184·752	1·31	0·032	1886·40	13·41	0·335
2.	Common bar, Shropshire ...	5202·72	37·08	0·927	2437·92	17·37	0·434	254·592	3·24	0·081	3028·32	21·59	0·540
3.	Best bar, Staffordshire	1772·64	12·63	0·316	2376·00	16·93	0·423	223·344	1·59	0·039	2026·08	14·44	0·361
4.	Best Welsh bar, Doulais......	1559·52	11·11	0·278	3581·28	25·52	0·638	201·024	1·43	0·035	1980·00	14·11	0·353
5.	Low Moor boiler plate	1209·60	8·62	0·215	2269·44	16·17	0·404	200·880	1·43	0·035	1864·80	13·29	0·332
6.	Common boiler plate, Banks.	1526·40	10·88	0·272	3107·52	22·15	0·554	216·000	1·54	0·038	2312·64	16·48	0·412
7.	Swedish bar, Dannemora ...	1558·08	11·10	0·277	4072·32	29·02	0·726	169·776	1·21	0·030	2640·96	18·82	0·470
8.	Faggotted scrap bar	362·88	2·58	0·064	2126·76	15·15	0·379	136·656	0·97	0·024	1245·60	8·73	0·219
9.	Blister steel bar, soft	1680·48	11·98	0·298	2397·60	17·09	0·425	86·544	0·61	0·015	1751·04	12·10	0·301
10.	Shear steel bar, soft	1766·88	12·59	0·313	3810·24	27·15	0·676	145·728	1·04	0·025	2191·68	15·62	0·389
11.	Cast steel, tilted bar, soft ...	1926·72	13·73	0·441	3149·28	22·44	0·559	147·312	1·05	0·026	1735·20	11·22	0·279
12.	Cast steel, tilted bar, hard ...	1349·28	9·61	0·239	2424·96	17·28	0·430	247·824	1·76	0·043	881·28	6·28	0·156

Report of the Committee, consisting of Sir JOHN HERSCHEL, *the* MASTER OF TRINITY COLLEGE, *Cambridge, the* DEAN OF ELY, *Dr.* LLOYD, *and Colonel* SABINE, *appointed to conduct the co-operation of the British Association in the system of Simultaneous Magnetical and Meteorological Observations.*

IN this their Fifth Report on the momentous subject entrusted to them, your Committee propose to follow the arrangement of the matter under the several heads adopted in their report of last year, and in nearly the same order, as on the whole most convenient and perspicuous.

1. *Antarctic Expedition.*

The Committee congratulate the Association on the approaching return of this expedition, having accomplished in the fullest degree all the objects of its mission. Three seasons in which they have forced their way at different points far within the higher latitudes of the southern hemisphere, have furnished a magnetic survey of these regions equalling, or rather surpassing, both in completeness and accuracy, all those sanguine expectations which led the Association to urge on the Government the prosecution of this great enterprise. Though not marked by geographical discoveries of equal splendour with those which signalised their first campaign in the Antartic Circle, and which we had the gratification of noticing in our last report, the two succeeding seasons have each produced an equally rich harvest of magnetic results.

The observations as they have reached England have been committed for publication (as noticed in our last report) to the superintendence of Colonel Sabine, and under the form and in continuation of a series of "Contributions to Terrestrial Magnetism," are in process of communication by him to the Royal Society, and of publication by that learned body in their Transactions. In our last report we gave some account of a communication of this description, in which the observations made between England and Kerguelen's Island are published and discussed. The 5th of these series (which is now in progress of printing) contains, comprised in about sixty pages of tables, the observations within the Antarctic Circle, made in the summer of 1840–41, on board of both the ships, as also those on board of the Erebus, between Kerguelen's Island and Van Diemen's Land. In this paper the important subject of the corrections due to the iron of the ships is fully considered, and by the aid of formulæ furnished by Mr. Archibald Smith of Trinity College, Cambridge, and founded on the theory of M. Poisson, delivered in his Memoir of 1838, "Sur les déviations de la Boussole produites par le fer des Vaisseaux," the constant coefficients of these corrections for each ship are investigated. These coefficients are four in number for each ship, falling naturally into two pairs, the one depending on a series of compass azimuths observed and compared with the true azimuths round a whole revolution of the ship's head at a fixed station; the other on a series of inclinations or dips observed in the same situations of the ship, and compared *inter se.* Observations for this express and most important purpose were made (in conformity with the general instructions) at several stations, viz. at Chatham, before the departure of the expedition, at Hobart Town (Van Diemen's Land), and at Auckland Island. From these Colonel Sabine has obtained three sets of values of the former pair, and two of the latter, and the results thus procured (by no trifling amount of calculation) are found to agree admirably; thus affording ground for the fullest confidence in the corrections depending on them, as well as in the theory from which they are derived, and in the general approximation to truth of the hypotheses necessarily made as to the distribution of the iron in the vessels. In the case of one of these coefficients an opportunity was afforded of testing its value by a series of observations made in a high south latitude, by employing a different formula involving the true dip, as actually observed on the ice at the moment; and the result proved in perfect accordance with the mean of those deduced by the other method.

There is one other constant, which affects the intensity, entering as a general multiplier for the reduction of the observed to the true intensity. The value of this for the Erebus is obtained by Colonel Sabine from a series of observations made at Hobart Town with Mr. Fox's intensity apparatus, similarly instituted throughout a complete revolution of the ship's head; the partial results of which, grouped by pairs, and checked by the use of observed in place of computed values of the disturbed inclination, offer an agreement highly satisfactory.

The above statement applies to the Erebus. For the Terror the first pair only of constants (those depending on the azimuths) are deduced; from observations at Chatham and Hobart Town, the constants for correction of the dip and intensity could not be obtained, the requisite observations not having yet reached England.

Besides these there are a variety of index corrections and other elements for the observations of inclination and intensity, which having been computed and duly applied, the tabulated results have been projected by Colonel Sabine in three charts (copies of which accompany this report), exhibiting both the individual results, and the approximate course of the isogonic and isoclinal lines deduced from them, an inspection of which gives room for several interesting remarks.

1. As great and greater discordances are to be looked for, and must frequently be experienced in magnetic surveys conducted on land, than in those at sea. In effect, the chief and worst cases of discordance occur in observations made on the islands at which the expedition touched.

2. The general form of the curves of higher inclination in the southern hemisphere is much more analogous to that in the northern than appears in M. Gauss's maps.

3. Captain Ross's observations of intensity lead also to the conclusion of a much closer analogy between the two hemispheres than M. Gauss's maps would appear to indicate. No higher intensity than 2·1 has been any where observed.

4. In examining the observations of declination, particularly those which point out the course of the lines of 0° and 10° east, a more westerly position is indicated than that assigned by M. Gauss for the spot in which all the lines of declination unite.

It cannot be indifferent to the British Association to learn, that first, by the blessing of Providence, and next by the watchful care and the experienced judgment of the Commander of the Expedition, all those results have been obtained without any of those drawbacks to which, from the duration and peculiar hazards of the voyage, it might perhaps have been deemed unusually liable. Captain Ross closes his last dispatch to the Admiralty, dated from the Cape of Good Hope in April 1843, with the following remarkable sentence:—"It affords me the highest gratification for a third time, to report that our ships have sustained no material damage; that we have not been visited by casualty or sickness, and that there is not an individual in either ship in the Sick Report."

2. *British and Foreign Observatories.—Publications of Magnetic Observations and Memoirs, &c. relating to Terrestrial Magnetism and Meteorology.*

The government of the United States have appropriated funds for the establishment of a magnetic observatory at Washington under the direction of Lieut. Gillies of the United States Navy. This gentleman has lately visited Europe for the purpose of obtaining instruments for this observatory, as well as for a national astronomical observatory, which is also placed under his direction.

The United States government has also appropriated funds for the support during three additional years of the Magnetic Observatory at Philadelphia, under the direction of our zealous and accomplished Corresponding Member Professor Bache.

In consequence of an application made by the President and Council of the Royal Society, through the Secretary of State for Foreign Affairs, to the Bavarian government, the Magnetic Observatory at Munich, which under Dr. Lamont has rendered such good service to the magnetic cause, has been continued for three additional years. The results of the first three years, 1840, 1841 and 1842, have been published in a memoir in the Bavarian Academy of Sciences, which has been translated in the 12th Part of Taylor's Scientific Memoirs.

A second volume of the magnetic and meteorological observations made at the Prague Observatory has been published by M. Kreil, containing the regular observations for August 1840 to July 1841, and the disturbance observations from September 1839 to Nov. 1840.

The publication of the regular observations made at the Magnetic Observatory at Christiania, under the direction of the veteran and indefatigable Professor Hansteen, are preparing for publication at the expense of the Norwegian government. They consist of an unparalleled series with the unifilar magnetometer, observed at every ten minutes night and day, from November 1841 to the end of June 1843: accompanied by observations of the bifilar at every second hour from June to December 1842, and since that period hourly.

M. Gauss has published in the last volume of the 'Resultate' a laborious analysis of the observations made with the inclinometer, and an examination of all the sources from whence error may introduce itself into the results. This memoir, which is calculated to be of much practical use, has been translated in the 12th Part of Taylor's Scientific Memoirs. The testimony which M. Gauss bears to the excellence of the inclinometer made by the late Mr. Robinson, must be very grateful to the friends of that much-regretted artist.

The publication of the observations at the British colonial stations still awaits the exact determination of the temperature coefficients, for which object an auxiliary apparatus has been sent to each observatory. The first part of the volume of the disturbance observations has been completed, comprising those made in 1840, 1841. The reasons for separating these observations from the general series, and commencing the publication of the results obtained at the magnetic observatories with them, have been assigned in our last report. Colonel Sabine has prefaced this volume with a synoptic statement of the general conclusions which it has been found practicable to deduce from the observations in their actual uncorrected state (the temperature corrections being for the most part, and the scale-coefficients, in certain of the series still wanting*), some of the more important of which it will be proper here to mention.

* The reasons for printing these especial observations in the absence of these essential elements for their correction, will be found in the preface alluded to. It was not resolved on without full consideration.

The object of this publication being to present in their most salient point of view the *irregular* movements of the needle and variations of the magnetic force, it is necessary in the first instance to ascertain and subduct from the observed changes everything of a regular periodical nature which the actual amount of our present knowledge has enabled us to ascertain. This has been accordingly done, so far as Toronto and Van Diemen's Land are concerned, both for the diurnal, monthly, and annual fluctuations of the magnetic elements as far as it has been practicable yet to deduce them, and the results have afforded room for preliminary conclusions of no small interest, which have been stated by Colonel Sabine in his preface, and of which the following is a brief outline.

At Toronto the regular diurnal movement in declination does not consist in a simple uninterrupted progress and regress of the needle. Commencing from 2^h P.M. its movement is continuous to the eastward till 10 P.M., it then returns westward (through a comparatively small angle) until 2^h A.M., when its eastward movement is resumed and continued till 8^h A.M., after which its return is continuous to the west until 2^h P.M. This second eastward progression is more decided in summer than in winter, and the total range of diurnal fluctuation is also more considerable.

At Van Diemen's Land (a station it is to be borne in mind almost antipodal to Toronto), the course of the diurnal oscillation corresponds with that above stated in all but one essential feature, viz. that the hours (in mean time at the station) of easterly movement of the north end of the bar at the one station are those of its westerly movement at the other, that the diurnal range being nearly the same in both, with a similar inequality in its summer and winter amount; a similar alternate progression and recess also prevails, and at the same hours.

These are certainly very remarkable features, showing a *regular* connexion between two stations so remote, carried out into what may be regarded as minute particulars. Falling in however with the generally received impression of the universality of the causes (whatever they may be) which produce the periodical fluctuations of the magnetic elements, they can only be regarded as contributions to our knowledge of details. It is otherwise with the results deduced by a comparison with each other of the observations recorded in this volume, not only at these two stations but also at St. Helena, and with those made by M. Kreil at Prague, as respects cases of unusual magnetic disturbance which occur (so far as we can yet perceive) casually, or at least non-periodically. Such comparison has enabled us at length, unequivocally, to state it as a general proposition, that the whole magnetic system of our globe is affected in the majority of cases of great disturbance. For it is found that if a list of days of great disturbance, independently noticed as such, and marked by extra observations on each station, be made out, these lists will be found to coincide in at least a majority of days, and more especially on those days when the recorded disturbances have been greatest. Of twenty-nine principal disturbances recorded in Colonel Sabine's Synoptic Table, some confined to a single day, others running through two or three successive days, and comprehending altogether forty-nine days, by far the greater part are shown to have manifested themselves at Toronto, Van Diemen's Land, and Prague, and fifteen are marked by extra observations at St. Helena.

But though it is thus rendered certain that the whole globe is affected in many and great "magnetic storms," it is equally shown that the minute identity of particular shocks, which seemed to result from the earlier observations of this nature in Europe, cannot be maintained (as a general proposition) as traceable on anything like so extensive a scale.

Not the least interesting part of this volume consists in the notices at Toronto of auroral phænomena accompanying the extraordinary magnetic disturbances. They are many and remarkable, and can hardly fail to throw great light on this branch of the general subject.

This is not the proper place for theory, nor is anything more than an analogical illustration intended, if we compare the affections in question to what might be supposed to occur if we conceived the earth surrounded, besides the ocean and the air, with an electric atmosphere of excessive elasticity and mobility, in which were propagated from origins unknown to us, undulatory movements of every order, from the most minute local oscillations to waves affecting (almost in an instant, or in very short intervals of *time*, but varying in depth and amplitude with the geographical coordinates) its whole extent. Could such electric waves* be conceived as affecting the magnet, we might, form some idea of the mode in which particular shocks thin off as it were by distance of place, and are replaced by others of different local origin.

The difficult subject of the determination of the earth's magnetic force in absolute measure has been subjected to a further investigation by Dr. Lloyd. The difficulty, which is of a practical rather than a theoretical nature, arises from this, that the expression for the tangent of the angle of deflection of one magnet by another being expressed approximately by two terms of a series according to descending powers of their mutual distance, viz. the inverse cube and fifth power, with unknown coefficients, these have to be determined in Gauss's method by observations of deflection at two different distances, and by eliminations, in which process serious errors are introduced in the result by small errors in the observations. The object of Dr. Lloyd's present paper is to point out a means by which the quantity sought may be obtained without elimination, by observations at one distance only, thus diminishing both the trouble of the observation and increasing the accuracy of the result. This method depends on the assumption of an empirical law in the distribution of free magnetism in a magnetised bar inferred by Biot from Coulomb's researches, in virtue of which a simple ratio, dependent only on the lengths of the two magnets, subsists between the coefficients of the inverse powers above mentioned,—a ratio such, that on a certain simple assumption of the proportional lengths, the term depending on the inverse fifth power may be made to vanish *ipso facto*, and thereby get rid of the whole difficulty. Dr. Lloyd adduces several experiments confirmatory of these results.

The 'Annalen fur Meteorologie, Erdmagnetismus und verwandte Gegenstände,' published by M. Lamont with the assistance of Messrs. Grünert, Koller, Kreil, Lamont, Pleiniger, Quetelet, and Stieffel, for the year 1842, is completed, and will be followed up by similar series in quarterly parts. In this collection are contained a multitude of important contributions to these subjects from all quarters, and more particularly magnetic observations from Munich by M. Lamont; and meteorological registers from Marseilles by M. Benjamin Valz, from Schlösse by M. Bayer, from Dorpat by M. Mädler, from various stations in Labrador and Greenland, from Utrecht by M. Van Rees, from Munich by M. Leonhardt, and a series of comparative observations from Stuttgard, Giessen, Carlsruhe, Vienna, and Parma, in which the barometric and thermometric observations are not stated absolutely, but only their dif-

* It is by no means necessary in this way of conceiving the subject, to assume an atmosphere of pure electricity (of which we can form no conception). But we may, for hypothesis sake, admit the existence of an atmosphere of some medium very much more rare and elastic than air, by whose compressions and dilatations electricity may be momentarily developed and absorbed, as caloric is by those of air in the phænomena of sound, manifesting itself by its action on the magnet, and possibly by auroral pulsations also, of which latter phænomenon it seems excessively difficult to give any other account.—(H.)

ferences from Munich, an arrangement of which it is not very easy to perceive the advantage. The volume in question contains also an investigation by Dr. Lamont of the law of distribution of magnetism in magnetised bars, in which various methods of determining by observation the coefficients of an empirical series representing the intensity of free magnetism in ascending powers of the distance of a point from the centre of the magnet are proposed.

By a communication from M. Boguslawski it appears that in spite of great difficulties arising from want of regular assistants the observations at Prague have been regularly continued, not only on all the term days, but, since January 1st of the current year, also daily at four hours in each day with all the three instruments. Perceptible magnetic disturbances have been noticed by him on January 1, October 6, February 24, March 29 (very great), April 5, May 15, and July 24.

3. *Magnetic Surveys.*

At the request of the East India Company the magnetic observatories of Simla and Singapore have been supplied with a portable magnetic apparatus, which we hope will be speedily and extensively employed in magnetic surveys having the respective observatories as central points.

M. Kreil is about to add to his most useful observatory labours a magnetic survey of Bohemia, for which he has obtained portable apparatus on the construction proposed by Dr. Lamont.

4. *North American Survey.*

Letters have been received from Lieut. Lefroy dated from Lachine on the 28th of April, and from Sault S^te^ Marie, May 20th of the current year, giving an interesting account of his progress so far on his arduous expedition, and detailing his plan of operations, for this and the next year with a sample of each day's performance. Lieut. Lefroy reached Montreal on the 22nd of April, where also his instruments arrived on the 25th (not altogether without injury to the force of his magnets from the extreme badness of the roads). Here, on consultation with Sir G. Simpson, he found it advisable to recast the plan of his route and to resolve on proceeding first to York Fort, and returning thence to Norway House, ascend the Sascatchewan to Edmonton, which he expects to reach on the 20th of September, whence, crossing the Uniga to descend it on the ice to the Slave Lake and return to Athabasca for the remainder of the winter, working his way back to Canada in the next season and taking Moose Fort on the way back. By the adoption of this route a more complete circuit of the focus of maximum intensity will be accomplished than by that originally contemplated. Every necessary order and instruction and every facility he states to have been most readily accorded, and in particular a circular to have been issued to all the officers of the Hudson's Bay Company, amounting to a *carte blanche*, commanding all the resources of the Company. The line of no variation Lieut. Lefroy states to have been crossed between La Cloche and Sault S^te^ Marie, up to which point little change of dip had been experienced, his course leading him nearly along the isoclinal line of 77°.

5. *Naval Observatories.*

The second series of Sir Edward Belcher's magnetic determinations at thirty-two stations, principally at ports in the Pacific Ocean and in the Indian and Chinese Seas, have been reduced by Lieut.-Colonel Sabine and printed in the 2nd Part of the Phil. Trans. for the present year. The two series of Sir Edward Belcher's observations, which are now printed in the Phil. Trans., contain determinations of the three magnetic elements at sixty-one stations widely distributed over the surface of the globe; and that indefatigable officer has again sailed for the coast of China and the Pacific, furnished with an improved magnetic equipment, including the portable magnetometer apparatus and a Fox's inclinometer and intensity instrument for observations at sea.

The observations from Captain Blackwood's expedition have begun to arrive, both those with Mr. Fox's instrument at sea and with the portable apparatus on occasions on shore. The observations of this expedition promise to be of great value, from the zeal and intelligence which those already received evince on the part of Lieut. Shadwell and Mr. Evans, under whose particular direction this branch of the public service has been placed by Captain Blackwood.

No expense whatever has been incurred in the present year, but your Committee pray the continuance of the grant made to them at the last meeting to meet such demands as may arise.

Signed on the part of the Committee, J. F. W. Herschel.

Report of the Committee appointed for the Reduction of Meteorological Observations. By Sir J. F. W. Herschel, *Bart.*

Every exertion having been used to complete the series of equinoxial and solstitial observations during the years 1835, 1836, 1837, 1838, whether by writing to parties who have communicated observations, for duplicates of missing series, or by searching the records of observatories, meteorological registers, scientific journals and periodicals, these endeavours have proved so far successful, that at length 334 sets of observations have been collected, made at sixty-nine distinct stations. A synoptic statement of these, with the geographical elements of the stations, the names of the observers or communicators of the observations, and other particulars as far as they could be collected, or are necessary for our present purpose, is annexed to this report. See Appendix (A.).

It will be at once seen on inspection of this synopsis, that although at a few stations (as London, Greenwich, Brussels, Port Louis, Markree, Cadiz) consecutive series, extending over a period of three complete years, have been procured (within the limit assigned to these reductions), yet that this is not the rule but the exception; and that, taken altogether, the observations form anything rather than a connected whole. Under these circumstances, the only point of view which seemed to promise any distinct and definite results, bearing reference to causes prevailing over extensive regions, was that of the barometric fluctuations, considered with a view to the propagation of atmospheric waves, which, it is manifest, can only be traced over any considerable tract of country by this method of inquiry. It is accordingly to these, and to these only, that my attention has been directed; using the observed temperature (where the original observations have not been corrected by the observers) merely as elements of reduction, and referring to the registered state of wind and weather, whenever such reference has been considered elucidatory of any point suggested by the main branch of the inquiry.

If we consider the trifling depth of the ponderable atmosphere regarded as an envelope of the whole globe, the interruption and obstacles offered to its oscillatory movements as a whole by the configuration of the continents and the distribution of mountain chains, but above all, by the vast and capricious variety of local causes affecting the temperatures of particular districts, and thereby causing partial ascensional and descensional movements and local generations and precipitations of vapour, we shall clearly perceive that, so far as our present purpose is concerned, the particular dimensions and form of our planet have little to do with our inquiry, and that for the immediate purposes of that inquiry we may regard our globe as a plane surface of infinite extent, over particular districts of which systems of oscillation of local origin, and independent of each other, are in progress, and in which we may regard ourselves fortunate if we can now and then succeed in obtaining distinct evidence of the direction, extent, height and velocity of a single wave. The distribution of our stations into groups, grounded on this view of the subject, and the mode of referring the observations of each group to a central station within it, have been described in my report for 1840, and need not therefore here be recapitulated. These groups, it is true, abstractedly considered, are far from those which would be chosen *à priori*. For example, Mauritius and Van Diemen's Land are but ill adapted to form a group with Indian stations. But for this there is no remedy, and the Mauritius observations (of which, owing to the diligence and zeal of Captain Lloyd, Surveyor-General of that island, we possess a nearly complete series) merit and will receive a separate discussion.

Two objects have been chiefly kept in view in the present inquiry. First, the tracing, where it can be accomplished, the course of one particular wave over the whole area embraced within one of our groups; and secondly, where this cannot be done, the observation of connexions between particular localities with a view to the subdivision of the total area into barometric districts, in which the atmospheric fluctuations shall be, generally speaking, similar in their phases. With these objects the projection of the barometric curves, for all the stations of a group, one sheet for each separate term, has been executed with great care and delicacy by Mr. Birt, and on a scale so large as to allow of the minutest corresponding changes, if any, to be distinctly followed out. The number of sheets so projected is fifty-three, on a scale of an inch to the hour in time, and one inch to 0·066 of barometric altitude; and I must not lose this opportunity of acknowledging many valuable remarks received from that gentleman on the subject of particular cases of much interest, which will be given in his own words, under their several heads as they occur.

I proceed now, therefore, to the discussion of the observations of each term, so reduced and projected, seriatim.

As the whole of the curves of the American group, and seventeen others of the European series, together with their tabulated reductions, have been on a former occasion submitted to the inspection of the meeting, to the number of 105, it has not been thought necessary to risk the loss or damage of the remainder by transmitting them herewith, they being in all respects similar.

European Group.

June 1835.—This term affords only two series, those of London and Brussels. The projected curves exhibit a pretty regular descent, and tolerably well-maintained parallelism during the first sixteen projected hours, or until 3 A.M. of the 22nd, when the Brussels curve attains a minimum, and pretty abruptly ascends again to the end of the series. The London curve, on the other hand, continues to descend till 11 A.M. of the 22nd, where it also attains a minimum, and begins to reascend. If this minimum represent, as it probably does, the trough of a barometric wave which at 3 A.M. was vertically over Brussels, and at 11 A.M. over London, the wave must have been travelling westwards, but the direction of its length, and therefore that of its advance, remaining undetermined for want of other stations, its velocity must also remain so, only that it must have equalled or exceeded $12\frac{1}{2}$ miles per hour.

The effect of diurnal oscillation is evident in both these curves, but most so in the London one, by a *relative minimum* occurring at 4 P.M., and a *relative maximum* at 10 P.M. The morning minimum is also perceptible enough in the London curve, but the corresponding maximum cannot be traced in either.

September 1835.—Markree, London and Greenwich, Brussels, Geneva.

Diurnal oscillation.—In all the curves the afternoon and nightly minimum and maximum are perfectly distinct, and indeed finely developed. The morning and forenoon ones less so, except in the Geneva curve, where the forenoon maximum is very evident.

When these are abstracted and slight irregularities rounded off, the London and Greenwich curves exhibit a very steady fall during the whole series, amounting to 0·38 in. in twenty-six hours, and being perceptibly accelerated towards the end of the series. The same holds good for Brussels and Geneva, but at these stations the total fall is much less, viz. 0·11 in. for Brussels, and 0·07 in. for Geneva. On the other hand, at Markree, the descent, which from noon till midnight of the 21st had been gentle (amounting to 0·08 in.), begins then to accelerate, and terminates the curve with a bold and decided downward sweep, traversing no less than 0·59 in. in the subsequent thirteen hours. On referring to the observations of wind and weather on this occasion, this fall of the barometer appears to have been the precursor of a pretty stiff gale, which was also felt in London, from the south-west.

December 1835.—Markree, London, Brussels, Geneva, Gibraltar.

Diurnal oscillation.—Very conspicuous in every one of the curves, *both* the maxima and minima being unequivocally and strongly marked. When the effect of these is allowed for and abstracted, all the stations exhibit a steady, uniform, and (with exception of Markree, where it was somewhat slower) an *equally rapid* rise in the barometer during the whole extent of the projected series. Considering the season of the year and the extent of surface embraced, this must be allowed to be not a little remarkable. To take in an effect of this nature, we must enlarge our conception of an atmospheric wave till it approaches in some degree, in the extent of its sweep, and the majestic regularity of its progress, to those of the tide-waves in the ocean. The total elevation or barometric height of the portion of this wave within the limits of observation, amounted to about 0·22 in. on an average of the several stations, exclusive of Markree, where it did not exceed 0·16.

March 1836.—Markree, Limerick, Blackheath, Greenwich, London, Brussels, Maestricht, Geneva, Cadiz, Gibraltar, Tangier.

The effects of the regular diurnal oscillation are very distinct throughout the series for London and its environs, Brussels and Maestricht. The forenoon maximum on the 22nd is also very conspicuous at Geneva, but the morning minimum there is marked in its influence on the course of the curve by a very curious feature, of which more presently. In Markree, Limerick, and the south European stations, the diurnal oscillations are not traceable, or but indistinctly. Abstraction made of these oscillations, the English and Belgian curves agree in indicating a downward movement throughout the series, at the rate (nearly uniform) of about 0·14 in twenty-four hours. In this movement Geneva also agrees, with exception of one interruption arising from the singular feature above alluded to. But the Irish curves separate themselves in the most decided manner from this law of progress, and appear to have been under the influence of some cross wave, or local cause of disturbance not extending to any of the other stations. These curves both commence with a falling barometer, but a minimum is attained about 6 P.M. of the 25th (6^h), after which they rise rapidly, and continue to do so; in the case of Markree to the end of the projected series; in that of Limerick, nearly so, a maximum being apparently reached about the 25th hour (1 P.M. of the 22nd).

The curves for Cadiz, Gibraltar and Tangier, are all marked (and more especially the two latter) with that peculiarity which has already been noticed in the Geneva curve, and which consists in a sudden and temporary elevation and depression, forming a kind of hump or abrupt bulge upwards. At Geneva and Gibraltar this occupies the interval from the 11th to the 15th hour (11 P.M. to 3 A.M.). At Tangier it is two hours earlier, viz. from 9^h to 13^h, but in all three cases equally pronounced, and of about the same elevation, 0·033 in.; not a very large quantity, it is true, but quite unequivocal, and beyond all reasonable limits of error of observation. At Cadiz it also occurs, but less distinct and less abrupt, running into the swell caused by the nocturnal maximum of the regular oscillation, as is also in some degree the case at Geneva, and of which maximum it is probably some abnormal affection, rather depending on the general state of the atmosphere as affecting radiation (of which I shall have more to say presently), than the effect of any wave-like disturbance striking on the stations at the times in question. The winds and weather noted at the stations afford no elucidation of this curious peculiarity.

June 1836.—Markree, Limerick, Oxford, London (with Greenwich and Blackheath), Brussels, Hanover, Geneva, Turin, Cadiz, Gibraltar.

This term exhibits a considerable want of accordance between the British and continental stations. To begin with the latter. The diurnal oscillations are well marked at Brussels, Geneva and Turin, *both* the minima and *both* maxima being clearly exhibited. When these are abstracted the curves become nearly level, a slight tendency to descend only remaining for Brussels and Geneva, and to ascent for Turin. At Cadiz and Gibraltar also, the afternoon minimum and nocturnal maximum are clearly expressed, and being eliminated, the curves up to about the 14th hour at Cadiz, and the 17th at Gibraltar, assume the flattened and slightly-descending character of those belonging to Brussels and Geneva. But at these hours respectively a remarkable change comes on which completely masks the oscillatory movements. In fact, a bulge upwards rather than a depression takes place in the Cadiz curve between the 14th and 18th hours, and a sudden abrupt upward start (of 0·03 in.) in that of Gibraltar at the 18th, which as it were dislocates it, and places all the rest of its course on a higher level. In speculating on the origin of these peculiarities, I have been led to consider them as probably due to the immense radiation of the African continent, with its cloudless skies, chilling and contracting the superincumbent atmosphere, and giving rise to a nocturnal influx from all quarters, but chiefly from the adjacent ocean. Such an influx, suddenly checked and reversed in its direction by the approach of the sun to the eastern horizon, would evidently tend to produce phænomena of the kind.

The curve for Hanover of this term deviates totally from the type of those described, offering a regular and considerable rise and fall, in which the effect of the diurnal oscillations is completely merged. The maximum of the series occurs at or about 16^h, the total rise from the lowest point being 0·22 in., and that of its subsequent depression to what appears to be a minimum, at the end of the series, of 0·13 in. These features tend to separate

Hanover from the other European stations and to connect it with the British group, though under considerable modifications.

At all the British stations the effect of diurnal oscillation is completely merged in, and even for the most part contradicted by, the course of casual fluctuation. On the subject of these curves, as connected with each other, and with those belonging to the continental stations, Mr. Birt has furnished some instructive and elaborate remarks, to which it would be doing injustice not to state them in his own words.

"*British Isles and Europe.* June 1836.

"(B.) These sheets exhibit a beautiful and interesting instance of the transference of the atmospheric affections from the west of Ireland across England to Brussels.

"(B.) By taking the whole of the observations at Markree and Limerick, the curves obtained at these stations may be divided into three portions. The first exhibit a gradual descent of the barometer at both stations: this descent was observed during seven hours at Markree, and at Limerick during six; at Markree, the northern station, it was greater than at Limerick: the extents are as under.

Markree	·096
Limerick	·060

The vertices of these curves were not observed at either station, consequently the whole amounts of oscillation are not given, but as the descents terminate nearly at the same time, the oscillations are comparable.

"(B.) The second portions of these curves are distinguished by their flatness, and also, especially at Markree, by two complete, though small, undulations; these undulations are perceptible, although in a less degree at Limerick; they occupy nine hours at each station.

"(B.) The third portions exhibit a bold descent of the mercurial column; this descent commenced at Limerick at 9 P.M., and at Markree at 10 P.M.; at the latter station it is uncertain if the lower vertex was observed, but it is probable that it was observed at Limerick at 5 P.M. of the 22nd. Should the 6 o'clock observation at Markree have been the lowest, the extents of oscillation and the durations would have been as under.

Markree	·404	20 hours.
Limerick	·350	20 hours.

"From these facts it appears that the atmospheric movements were one hour in advance at Limerick, and that the extents of the undulations were greatest at Markree.

"(B.) The features of these curves were observed at Halifax, but at later periods; thus the curve obtained at Halifax commences with a fall of ·133; the vertex is not given, and the duration of the fall is at least sixteen hours; this fall terminated at 10 P.M., nine hours after the termination of the fall at Markree; the flatter portion of the curve is well marked, extending from 10 P.M. to 8 A.M., one hour longer than the similar portions at Markree and Limerick. At Halifax this portion has three complete, though small undulations; the extents are given in the table of features of small undulations. The termination of this portion of the curve at Halifax occurred at 8 A.M. of the 22nd, 10 hours after the termination of the similar portion at Markree. The last portion of the curve was as well marked as at the Irish stations. During the remaining ten hours the barometer fell ·176, and it is probable that it continued to fall, as this portion agrees with the last portions of the Irish curves.

"(B.) It appears that the times occupied in the transference from Markree to Halifax were nine and ten hours.

"(B.) The Oxford curve presents us with a portion of an earlier undulation; the upper vertex is not given. The first (lower) vertex occurred at 1 P.M., the fall from the commencement of the observations being ·055. The second (upper) vertex took place at 6 P.M., the rise ·019. From this point the features of the curve are similar to those of the Markree, Limerick, and Halifax curves, and from being more southerly, the curve is more readily comparable with that obtained at Limerick. The fall occupies twelve hours, extent ·103. The two small undulations are distinctly perceptible, although contracted both in length and height; they occupy about four hours. The last fall commences at 10 A.M.; the reading at 5 P.M. is ·003 lower than that at 6 P.M., but it is uncertain if this is the vertex. The times occupied in the transference of the phænomena are as under:—

From Limerick,

End of first fall	18 hours.
End of small undulations . .	13 hours.

From Halifax,

End of first fall	8 hours.
End of small undulations . .	2 hours.

"(B.) At London the principal features of the foregoing curves were apparent. The fall, which occupied twelve hours at Oxford, occupied only nine hours at London; the commencements of the fall were at the same hour, 6 P.M.; previous to this similar phænomena were observed at the two stations, with the exception of the earliest upper vertex, which occurred at London at 8 A.M. The next lower and upper vertices occurred at the same hours at both stations. Oxford exhibiting the greatest ranges, the mean coincidence of the vertices occurred at 3^h 30^m P.M. The smaller undulations, so apparent in the former curves, are nearly obliterated at London, and a rise of ·030, occupying seven hours, occurs in their stead. The commencement of the last fall at London and Oxford is identical.

"(B.) The comparison between the London and Brussels curves is highly interesting; the same undulations are exhibited, but at different times, and the same diminution of oscillation that has been traced across England is still apparent. The tables show these features very distinctly; and also that the small undulations that were scarcely perceptible at London were apparent at Brussels.

"(B.) Throughout the whole of these curves west of Brussels there are two very prominent features, namely, the descents of the barometric column anterior and posterior to the small undulations. The complete features of these descents are given in the table under the heads *Vertex* 4—, and *Fall,* after small undulations. The features of the small undulations form a separate table.

"The European group, including London and excepting Hanover, presents a set of similar curves, each exhibiting two complete undulations; these six curves may for convenience be subdivided into three minor groups, each pair consisting of stations comparatively near each other. The group consisting of the Cadiz and Gibraltar curves is highly interesting, especially on account of the abrupt rise at Gibraltar at 5 A.M. and 6 A.M. of the 22nd. By neglecting this rise, it will be seen that the two curves are very similar, and this would induce the opinion, either that the abrupt rise arose from erroneous observation or the non-application of a correction, or that some very local action took place in the atmosphere. In these curves, Cadiz and Gibraltar, we have two of the vertices coinciding in time to those at 5 P.M., the undulations in one series being *longer* than in the other, there is consequently a *displacement* on each side of this *central* vertex, the first* vertex occurring earlier at Cadiz than at Gibraltar, and the second later. The undulation at Cadiz is shallower than that at Gibraltar; the time it occupied was fourteen hours, and its depth ·063, while at Gibraltar the time was nine hours, and depth ·070. The next undulation is about the same length at both stations, the Gibraltar curve being two hours in advance of the Cadiz.

"(B.) The coincidence of vertices appears to have been generally exhibited at the European stations; also in England, as noticed in the remarks on the London curve; and not only did the Oxford curve exhibit a longer, but also a deeper undulation than the London curve. It may be remarked here that Oxford and London are similarly situated relatively to each other as Cadiz and Gibraltar.

"(B.) Geneva and Turin are the remaining European stations that exhibit a coincidence of vertices; Geneva, similarly situated with respect to Turin as Oxford to London, London to Brussels, and Cadiz to Gibraltar, generally exhibits a greater range than Turin. The Turin curve, after the coincidence of vertices, is one hour in advance of the Geneva curve.

"(B.) The Hanover curve appears to form part of a distinct system; it is to be regretted that we do not possess observations to compare with it.

"(B.) From the above remarks, it appears that the affections of the atmosphere were very different in the British Isles and Europe. Those in the former gave rise to very extensive barometric undulations, while the observations obtained from the latter group showed that the atmosphere was but slightly disturbed.

"(B.) The occurrence of the small undulations first observed at Limerick and Markree, and traced with only one exception throughout the two groups, is a very interesting feature in these curves, as well as the descent of the barometer immediately following them, and which took place at every station in the British Isles and Europe. The small undulations appeared to be very irregular, and on two occasions, when they were scarcely observed, the states of the barometric column were decidedly different, namely, falling at Limerick and rising at London. The time, however, of the duration of these undulations varies upon the whole but slightly, Halifax exhibiting the longest and Oxford the shortest period, being respectively ten and four hours at these stations.

* "There appears to be some discrepancy between the statement that 'the next undulation is about the same length at both stations' and the table. By consulting the curves it will be seen that the fall at Gibraltar from 8 P.M. to 5 A.M. consists of two undulations, although they are not so bold as those at Cadiz; assuming therefore that the fall agrees with the Cadiz fall from 10 to 4, we have

+ 10 P.M.		Cadiz.		+ 10 A.M.
	·062	8 A.M. —	·014	
+ 8 P.M.		Gibraltar.		+ 8 A.M.
	0·58	5 A.M. —	·012	

After these times, 10 A.M. and 8 A.M., the barometer fell at both stations, with the exception of the rise of ·008 at Gibraltar at 1 P.M.; this will make the fall at Gibraltar from 8 A.M. equal ·076."

"(B.) Tables illustrative of the coincidence of vertices.

Oxford and London.

Station	Vertex	Range	Vertex	Range	Vertex	Range	Vertex	
Oxford.	+	·055	− 1 P.M.	·019	+ 6 P.M.	·103	6 A.M.	Oxford longest.
London.	+ 8 A.M.	·039	− 1 P.M.	·018	+ 6 P.M.	·094	− 3 A.M.	

Geneva and Turin.

Station	Vertex	Range	Vertex	Range	Vertex	
Geneva.	+ 8 A.M.	0·64	− 6 P.M.	·050	+ 11 P.M.	Geneva one hour longer.
Turin.	+ 8 A.M.	·052	− 6 P.M.	·052	+ 10 P.M.	

Cadiz and Gibraltar.

Station	Vertex	Range	Vertex	Range	Vertex	
Cadiz.	+ 8 A.M.	·063	− 5 P.M.	,033	+ 10 P.M.	Cadiz five hours longer.
Gibraltar.	+ 11 A.M.	·070	− 5 P.M.	·033	+ 8 P.M.	

"(B). Features of the small undulations.

Markree.

Vertex + 21st	5 P.M.	4 hours	·024
" − "	6 "	1 "	·036
" + "	10 "	4 "	·015

Limerick.

Vertex + 21st	2 P.M.	2 hours	·003

The remainder a continuous fall.

Halifax.

Vertex + 21st	12 NIGHT	2 hours	·032
" − 22nd	1 A.M.	1 "	·019
" + "	4 "	3 "	·009
" − "	7 "	3 "	·039
" + "	8 "	1 "	·013

Oxford.

Vertex + 22nd	7½ A.M.	1½ hour	·014
" − "	9 "	1½ "	·014
" + "	10 "	1 "	·010

London.

A continuous rise .... ·030

Brussels.

Vertex + 22nd	5 A.M.	1 hour	·006
" − "	6 "	1 "	·003
" + "	7 "	1 "	·002
" − "	10 "	3 "	·005
" + "	12 NOON	2 "	·018

"(B). Features of the small undulations (*continued*).

Geneva.

Vertex + 22nd	2 A.M.	1 hour	·002
„ − „	4 „	2 „	·032
„ + „	5 „	1 „	·026
„ − „	6 „	6 „	·001
„ + „	8 „	2 „	·007

Turin.

Vertex + 22nd	2 A.M.	2 hours	·009
„ − „	3 „	1 „	·004
„ + „	7 „	4 „	·033

Cadiz.

Vertex + 22nd	4 A.M.	3 hours	·022
„ − „	8 „	4 „	·046
„ + „	10 „	2 „	·014

Gibraltar.

Vertex + 22nd	8 A.M.	3 hours	·012
„ − „	10 „	2 „	·029
„ + „	1 P.M.	3 „	·008

Station.	Vertex 1 +			Vertex 2 −			Vertex 3 +			Vertex 4 −		
	Time.	Dur. Hrs.	Extent.	Time.	Dur. Hrs.	Extent.	Time.	Dur. Hrs.	Extent.	Time.	Dur. Hrs.	Extent.
Markree	...	...	...	...	...	...	...	...	...	21 1 P.M.	7	·096
Limerick	...	...	...	...	...	...	...	...	...	21 12 NOON	6	·060
Halifax...	...	...	...	...	...	...	...	...	...	21 10 P.M.	16	·133
Oxford...	...	...	...	21 1 P.M.	7	·055	21 6 P.M.	5	·019	22 6 A.M.	12	·103
London .	21 8 A.M.	2	·018	21 1 „	5	·039	21 6 „	5	·018	22 3 „	9	·094
Brussels	21 1 P.M.	7	·038	21 6 „	5	·034	21 12 NT.	6	·029	22 4 „	4	·027
Geneva...	21 8 A.M.	2	·019	21 6 „	10	·064	21 11 P.M.	5	·050	22 1 „	2	·042
Turin ...	21 8 „	2	·006	21 6 „	10	·052	21 10 „	4	·052	21 12 NIGHT	2	·009
Cadiz ...	21 8 „	2	·017	21 5 „	9	·063	21 10 „	5	·033	22 1 A.M.	3	·038
Gibraltar	21 11 „	5	·060	21 5 „	6	·070	21 8 „	3	·033	22 5 „	9	·058

Station.	Small Undulations.					Fall.			
	Commencement.	Rise.	Fall.	End.	Dur. Hrs.	Commencement.	Dur. Hrs.	Extent.	End.
Markree ...	21 1 P.M.	·024	·021	21 10 P.M.	9	21 10 P.M.	20	·404	22 6 P.M.
Limerick ...	21 12 NOON	·003	·052	21 9 „	9	21 9 „	20	·350	22 5 „
Halifax	21 10 P.M.	·032	·036	22 8 A.M.	10	22 8 A.M.	10	·176	22 6 „
Oxford	22 6 A.M.	·014	·004	22 10 „	4	22 10 „	7	·081	22 5 „
London	22 3 „	·030	·000	22 10 „	7	22 10 „	8	·067	22 6 „
Brussels	22 4 „	·018	·000	22 12 NOON	8	22 12 NOON	6	·021	22 6 „
Geneva......	22 1 „	·002	·000	22 8 A.M.	7	22 8 A.M.	10	·075	22 6 „
Turin	21 12 NIGHT	·038	·000	22 7 „	7	22 7 „	10	·082	22 5 „
Cadiz	22 1 A.M.	·022	·032	22 10 „	9	22 10 „	8	·102	22 6 „
Gibraltar	22 5 A.M.	·012	·021	22 1 P.M.	8	22 1 P.M.	4	·055	22 5 „

Sept. 1836.—Markree, Limerick, Halifax, Oxford, London (with Greenwich and Blackheath), Brussels, Hanover, Geneva, Turin, Gibraltar, Cadiz.

This series affords a fine instance of a fluctuation traceable over the whole area embraced (though gradually modified from station to station), under circumstances permitting us to determine the direction, breadth, and velocity of transference of an atmospheric wave on a large scale with considerable certainty.

The diurnal oscillations are not only perceptible, but form pretty conspicuous features of most of the curves. To begin with the southern stations:—At Gibraltar the first projected minimum (that of 4 P.M.), and the second or morning minimum is thrown somewhat later than its regular epoch (to 5 or 6 A.M.). Both the maxima are distinct. At Cadiz the first minimum is concealed by a casual minimum superposed on it. The adjacent maximum (that of 10 P.M.) is also somewhat displaced, and thrown later than usual by an irregular elevation or protuberance, which is also traceable in the Gibraltar curve; but the second minimum and maximum (those of the morning and forenoon of the 22nd) are very distinct. At Turin and Hanover the effect of the periodical oscillations is barely perceptible. At Geneva and Brussels it is perfectly distinct, as it is also, and not to be mistaken, at London, Greenwich, Blackheath and Oxford. At Halifax, obvious errors in the reading of the instrument interfere, but at Markree and Limerick these oscillations reappear with perfect distinctness in the morning and forenoon of the 22nd.

When these are smoothed off, the charts offer a fine example of a very regular and steady wave advancing from N.W. to S.E., perfectly identifiable in its greater features, though somewhat modified in its progress. Beginning with the Irish stations, Markree and Limerick agree in presenting us with a gentle fall of the mercury throughout, only that at the latter of these stations the descent is somewhat accelerated towards the end of the series, and retarded in its earlier hours (from 6 to 8 hours), so as give rise to a relative maximum at $11^h\ 30^m$. At Halifax this descending tendency disappears. The curve consists of a slight fall at the commencement with a minimum (m^1) at 1 hour, followed by a steady rise continued for 13 hours, up to a maximum M^1 at 14 hours; whence it sinks with much regularity to the end of the series, terminating at the same level where it began. This maximum (M^1) I consider as identical with that which passed Limerick at $11^h\ 30^m$.

The Oxford curve begins with a pretty steady ascent, and rising with three rather remarkable sub-undulations (whose summits occur at 8 hours, 10 hours, 12 hours respectively), attains a maximum nearly coincident in respect of time with that of Halifax, and descends somewhat more abruptly than it rose, to the end of the series. The crown of the wave was vertically over Oxford at $13^h\ 20^m$.

In London and its environs the ascent of the wave occupies the whole of the first 23 hours. It is very regular and gradual, but with the same traces of a *preceding* minimum. The crown of the wave was vertically over this locality at 22 hours, and the beginning of its descent is decidedly marked.

At Brussels and Hanover the whole series is occupied by the ascending wave. Its summit, if vertically over either of these stations at all within the series, must have been so nearly at its termination, or at 25 hours.

The cuive for Geneva commences with a slight fall and a decided and broad minimum extending over the 2nd and 3rd hours, clearly demonstrating the presence of the trough of a preceding wave. This having passed over to the south-east, the rise of our wave commences, and is maintained almost or quite to the end, where, however, some indications of a commencing descent may be observed.

At Turin, the trough of the preceding wave was here, as at Geneva, in the act of passing during the earlier hours of the series. It is perfectly well made out, the epoch of the minimum being 3 hours, which is followed by a steady rise to a maximum, which here, as at Geneva, is just perceived to be on the turn where the projected series breaks off.

At Cadiz, not only the minimum or trough of the preceding wave, but some considerable portion of its descent comes into view in the earlier hours, indicated by a falling barometer from 0 to 5 hours, where the minimum occurs. The rest of the series is occupied by the subsequent ascending wave, which continues to the 24th hour. Its course however is less uniform; its upward slope marked by an exaggeration of the forenoon maximum; and its turn downwards at the end of the series unequivocally expressed.

In the Gibraltar curve the barometer readings for the 4th and 5th hour have been obviously misread by two-tenths of an inch. This being corrected, a very flat minimum extending over the 4th, 5th, and 6th hour appears, marking, as at Cadiz, the termination of the preceding depression. At 7 hours, and not earlier, the rise of the mercury began, and continued uninterrupted (except by the regular periodic oscillations) to the end of the series without any indication, within its limits, of a re-commencing descent.

From a review of the whole of this highly interesting term, the following conclusions may be drawn.

A perfectly well-marked and definite atmospheric wave passed over the British Isles and the west of Europe on the day in question, the crest of the wave having a direction nearly N.N.E. and S.S.W., and its progress being from W.N.W. to E.S.E. The half breadth of the wave, which occupied 26 hours in its passage, covered a space extending from Oxford in a direction perpendicular to that of the crest, to a point not far from Halle in Würtemburgh, which gives, by rough measurement on a map, about 540 miles, and a velocity of about 21 miles per hour. The barometric depth of this wave may be stated at 0·2 inch.

December 1836.—Markree, Edinburgh, Halifax, Oxford, London (with Greenwich), Ashurst, Brussels, Hanover, Kremsmünster, Geneva, St. Jean de Maurienne, Turin, Gibraltar, Cadiz.

The effects of the regular diurnal oscillation are tolerably distinct in the curves for London, Greenwich, Oxford, Turin, and Geneva, especially as respects the maximum at 22 hours, which appears to have been at all of these stations exaggerated into a considerable upward bulge, as it is also at Kremsmünster, Hanover, and Brussels, where the other maximum and the minima are much less conspicuous. At Gibraltar the bulge in question assumes the character of a sustained elevation; at Cadiz, that of an undulating level. In the former of these two stations the other maximum and the minima disappear entirely, the curve presenting nearly a dead level from 0 to 7 hours, which is resumed after a trifling fall at the 8th hour, and continued to the 20th. In the latter the morning minimum is not only obliterated, but converted into an abrupt protuberance, occupying the interval from 14 hours to 17 hours,—a feature which I have already had occasion to notice in the terms of March and June 1836, and which appears to constitute a remarkable peculiarity in the diurnal movements of the atmosphere in this corner of the European continent. At Markree, Edinburgh, and Halifax, neither of the regular maxima or minima can be clearly made out.

Abstraction made of the periodical oscillations, the features of the continental curves, taken as a whole, offer little accordance. The range is least (and very small) at Brussels and Gibraltar, especially the former, corroborating a general remark to which my attention has been called by Mr. Birt, that Brussels may be regarded in some sort as a node of barometric undulation, departing from which on either side the range increases; a remark to which I shall subsequently have occasion to call attention more pointedly. Geneva, St. Jean de Maurienne and Turin, agree in the maintenance of nearly an uniform level (a slight downward tendency being only noticeable at Turin) for the fourteen hours from 0 to 14 hours, when they all begin to sink to a feeble but distinct minimum between the 17th and 18th hours, rising again to a maximum at the 22nd, which (as observed above) being more than is due to the regular oscillation, must be looked upon as belonging to a passing wave. Kremsmünster belongs also to the same system, but the descent of its curve from 0 to 16 hours is greater than at Turin (amounting to 0·09 inch), and marked by two conspicuous undulations in the 4th and 6th hours, which however are merely local, as they do not appear in any of the associated curves.

The minimum and maximum of the 17th and 21st hours are hardly more marked than what the periodical oscillations will account for.

Hanover is, *as usual*, peculiar. The slight tendency to fall as far as the 5th hour, and preservation of a level from thence to the 12th, indeed would tend to connect it with the former system, but instead of going on thence to a minimum, the curve begins thence to rise slowly but steadily as far as the 21st hour (through 0·03 inch), when again a slight but abrupt protuberance at the 22nd hour recals the corresponding feature in the Geneva group.

In Britain the Ashurst curve is interrupted from the 7th to the 18th hour, but where traced is nearly identical with those of London, Greenwich, and Blackheath; and we may add also, with slight modifications, of Oxford. All these four curves agree in a minimum between the hours 0 and 1 of a very flattened character, followed by a gentle rise of about 0·08 inch, which continues to the 18th hour, where in London and Ashurst a trace of the Geneva minimum occurs, followed, in these as well as at Oxford, by the protuberance already noticed in the Continental system.

Proceeding thence to Halifax, Edinburgh and Markree, the range increases, and the curves undergo a great change of character. In the curves of all three, indeed, a minimum in the beginning of the series, and a rapid downward tendency at its termination, connect them with the other members of the group, but in the intermediate hours their course is very different. Halifax rises to a bold maximum at 3 hours, through a range of 0·20 inch, after which it descends again with equal decision to the end of the term. Edinburgh is marked through its whole course with sudden ascents and descents, of a very desultory character, neglecting which, if a flowing curve be drawn, we find it rise, as in the case of Halifax, to a single strong maximum at 10 hours (or 5 hours earlier than at Halifax), and thence descending again to and beyond its initial level, giving a total range of 0·13 inch. The wind, which was moderate or light at Edinburgh during the afternoon of the 21st, gives no clue to the explanation of an extremely abrupt zigzag in the curve at 3 hours and 4 hours, which therefore have probably originated in misreadings.

The Markree curve rises from its minimum at 0 hour to a maximum at 12 hours, through 0·12 inch, thence retains its level nearly unchanged till between 17 and 18 hours, when the rise to the diurnal maximum commences, followed by a pretty decided slope downward, which beyond the limits of the projected curve (as the continuance of the observations show) became rapid, and was accompanied by a gale of wind from the west. A heavy gale from the same quarter is also noted at Halifax attending the decline of the barometer at that station, and at Edinburgh it is also recorded as freshening to a moderate and ultimately to a "high" wind; the strength of the wind in each case increasing with the barometric depression.

March 1837.—Markree, Halifax, Edinburgh, London, Greenwich, Brussels, Hanover, Geneva, St. Jean de Maurienne, Turin, Kremsmünster, Cadiz, Gibraltar, Tangier.

This term presents nothing very distinct. The barometric ranges for the most part small, and where moderately large not well agreeing. The following may be noted as features of some interest.

Diurnal oscillations.—Very perceptible at London, Greenwich, Brussels, Geneva, Kremsmünster.

Range.—Very small at Brussels, Hanover, Gibraltar, Tangier. Greatest at Markree, Halifax, Kremsmünster. The nodal character of Brussels may be regarded as supported by the observations of this term on the whole.

Sudden and broken undulatory movements.—Remarkable at Edinburgh from the 12th to the 17th hour.

Abnormal protuberances.—At Gibraltar, as already noticed in the terms of 1836, a low and unequivocal rise and fall from 14 to 18 hours, where, according to the law of periodicity, the reverse ought to have happened. A *relative* protuberance, similar, no doubt, in character, occurs at Cadiz in the interval from 13 to 16 hours, though (owing to the generally descending course of the curve from the 11th to the 16th hour) it rather appears as an abrupt shoulder than as a positive elevation.

St. Jean de Maurienne and Geneva, both offering a good deal of irregularity, yet preserve a good parallelism, notwithstanding the intervening Alps, high among which the former is situated.

June 1837.—Markree, Halifax, Oxford, London, Greenwich, Ashurst, Brussels, Hanover, Drachenfels, Kremsmünster, Geneva, Turin, Cadiz, Gibraltar, Tangier.

Diurnal oscillations.—Nowhere well made out. At Cadiz and Gibraltar the place of the 16^h minimum is occupied by an abnormal maximum of the character already so often noticed.

Term fluctuations.—At Markree, Halifax, London, Oxford, Brussels, a regular and (with exception of Markree, where the curve is considerably convex on and near 12 hours) a nearly uniform rise, at nearly the same rate in all, of about 0·01 inch per hour.

Beyond Brussels, in this order of sequence, the character changes. At Drachenfels the rise was trifling till the 9th hour, when a sudden jump upwards of 0·086 took place, which (as Mr. Forbes's barometer was of course a portable one) might be owing to some accident; especially as the subsequent course of the curve is level, or nearly so, as far as 16 hours, when it begins to rise in correspondence with the Brussels curve.

Hanover and Kremsmünster fall rather than rise, though but very slightly, during the first 4 or 5 hours. Both thence rise slowly till 15 hours, then pretty suddenly. In the Hanover curve the rise continues to the end. And at Kremsmünster it extends only to 20 hours, where a flat maximum is attained, followed by a slight but continued depression to the end of the series.

Geneva and Turin hold a kind of reversed parallel; the former, after some undulation, rising to a maximum at 12 hours, and thence falling to 14 hours; the latter falling to a minimum at 6 hours, and thence rising until 4 hours. After these epochs respectively both curves run nearly level to the end.

Cadiz fluctuates much and irregularly, Gibraltar little, and Tangier maintains throughout an almost unbroken level. Neither of the three offer any features of resemblance to the other curves already described.

Little more can be gathered from this term than that a general rise of the barometer took place during its continuance in the north of Europe, which was only partially participated in, in its middle, and hardly at all in its southern regions.

Dec. 1837.—Markree, Edinburgh, Halifax, Cambridge, Oxford, Ashurst, London, Greenwich, Brussels, Hanover, Kremsmünster, Geneva, Turin, Cadiz.

The principal feature of this term is a complete separation of Turin from all the stations north of the chain of Alps as well as from Cadiz, both in respect of the amount and character of its barometric fluctuations. In the curve for this station a gentle rise throughout the series of about 0·13 inch, with a flattened minimum in the earlier hours, a somewhat undulating and gentle rise to a relative, or in some cases to an absolute maximum, during the greater part of the projected 24 hours; a slight tendency to depression in the morning and forenoon of the 2nd day of the term, and a resumption of the gentle rise to the end of the projected series, may be taken as the general character of the curves; in which the diurnal maxima and minima are for the most part conspicuously traceable, and which, when allowed for, equalize several of the curves nearly into regularly sloping lines, with a slight general convexity. This is especially the case with Brussels, Greenwich, London, Ashurst, and Oxford; the curve for Brussels being decidedly the *smoothest* of the whole series. In Markree and Cambridge absolute maxima occur at the 14th hour, which is followed at Markree by a very gentle and continued depression; while at Cambridge, after descending to a pretty abrupt minimum (at 17 hours), the rising tendency is resumed and carried out to the end. At Halifax the rise is continued till between 16 and 17 hours, when an absolute maximum occurs, followed by an undulating level. At Geneva also there is an absolute though slight maximum from 13 to 14 hours, followed by a very slightly undulating level to the end. At Kremsmünster the early minimum (as is also the case at Geneva) is more marked and prolonged than can be referred to the action of the diurnal oscillation. In fact the Kremsmünster curve consists of two unequal portions like a vibrating string, having a node at the 15th hour, the earlier portion being concave, the later convex upwards; the deflexions in both, however, being small, viz. 0·03 inch and 0·05.

Hanover is again peculiar; as far as the 17th hour its curve follows the same law of gentle and undulating rise; but here a sudden irregular action commences, indicated by a great protuberance caused by a rapid rise of 0·10 inch to a maximum at $8^h\ 36^m$, sinking thence to a minimum at the 22nd hour, and again rising to the end.

From the type of all these curves that of Turin differs entirely. It commences by a gentle descent to a slight minimum at $2^h\ 36^m$, from which it nearly recovers by an undulating rise as far as $5^h\ 36^m$, when it takes a sudden plunge down of 0·086 inch to an abrupt minimum at $6^h\ 45^m$; whence it immediately recovers, and in the three next hours ascends through 0·132 in. to a maximum at $9^h\ 45^m$, then descends unsteadily through 0·067 inch to another minimum; after which follows a gentle rise to the end of the term. Nothing can place in a clearer light the action of the Alpine chain in intercepting a *small* wave, of which the undulations might be confined chiefly to the lower strata (since nothing prevents the atmospheric strata from being very unequally disturbed, as we see in the fluctuations of superposed liquids).

The curve for Cadiz commences, like that of Turin, with a gentle descent, and, like it, has a slight minimum at $2^h\ 36^m$, whence it recovers, not as at Turin, by violent starts and falls, but by a very gradual and easy slope up to $12^h\ 13^m$, when it again descends. From $13^h\ 36^m$ to $15^h\ 42^m$, however, we are reminded by a protuberance in the descending line, of the feature already signalized as a peculiarity of this station on former occasions.

Hitherto we have foreborne to mention the Edinburgh curve, which exhibits a strange anomaly, such as neither the course of the changes at Markree or Halifax would lead us to expect, and which, if it do not arise from some error of reading affecting the first 6 hours, goes to place in a strong light the capricious suddenness of the barometric changes at this station, of which we have already seen instances.

The Edinburgh curve commences, like the other British and many of the continental ones, with a slight fall to a minimum; anticipatory in this case of the regular diurnal minimum, viz. at $1^h\ 24^m$; thence it rises gently enough (through 0·059 in.) as far as $6^h\ 24^m$, when on a sudden it starts up, rising in the next 2 hours through 0·244 in., after which it maintains this increased level with only a very trifling variation up to the end of the series.

Dec. 1837.—Markree, Edinburgh, Halifax, Beaumaris, Oxford, London, Greenwich, Brussels, Alost, Louvain, Geneva, Kremsmünster, Turin, Parma, Cadiz.

This term is in every respect full of interest, and fortunately the stations are numerous and well-situated. It exhibits the rise, culmination, and fall of a great wave, travelling from north to south, or perhaps from north-west to south-east, and exhibiting at its culmination, at many stations very remote from one another, features giving it a peculiar character and individuality. The breadth of this wave was such that at no single station are both the rise and fall wholly included in the term; so that it is by successive stages as it were that each station contributes its quota to our knowledge of its progress.

Not a little remarkable either is it that Cadiz appears to have been entirely without its range, the barometrical curve of that station exhibiting nearly a level, varied only by the diurnal oscillations, which are unusually and strikingly prominent, and having, on the whole, a slight tendency to descent. Markree is the only other station in which (from the otherwise even and regular slope of its curve) these periodical movements are apparent.

The Markree observations, as projected, exhibit only the descent of the wave, its culmination having passed that station, or being in the act of passing it at the very commencement of the projected series or 0 hour. Referring to the original register in which 36 hours (6 before and 6 after the projected term) are included, I find this partly corroborated, the barometer having been on the rise during that whole interval. Nevertheless, as it will appear from a consideration of the other curves, that the wave had in fact a double crest, separated by an interval of several hours, it is not quite certain that the absolute culmination, or true maximum of pressure, is exhibited at all in the Markree series. The moderate downward slope of the Markree curve (which descends on the whole only 0·33 inch in the 30 hours registered from its apparent maximum) supports this idea, the total fluctuation, as it appears in the more southern stations, having been more than double this amount.

At Edinburgh the absolute culmination of the wave took place at 10 A.M. Ed. M.T.$=10^h\ 30^m$ Brussels M.T. of the 21st hour, being marked in a manner characteristic of the locality, by a very sudden upward start of a whole tenth of an inch in the hour preceding that epoch, and a fall of very nearly the same amount in the hour subsequent, producing a high peak or pinnacle in the barometric curve at that hour (22nd hour, Sept. 21), which, as it will be hereafter referred to, I shall term the *first* culmination of the wave. From the 11th hour the Edinburgh curve preserves its level as far as $1^h\ 30^m$ (Sept. 22), (1 30 P.M., Sept. 21, civil reckoning), when it dips for one hour to a slight minimum, and rises again to a maximum at 30 hours, thence descending to another minimum at $6^h\ 30^m$. Thus the interval from $2^h\ 30^m$ to $6^h\ 30^m$ is filled with the *second culmination* of our wave, which however is here not very marked, the whole descent to the minimum being only 0·046. To this succeeds a third culmination not quite so high as the second, and occupying 2 hours (to $8^h\ 30^m$), when a very abrupt and sheer descent commences for the next 3 hours (through 0·197 inch) to another minimum, or rather to a motionless level or pause in the descent, continued for 3 hours more (to $15^h\ 30^m$). From this point a very trifling rise takes place to a feeble culmination at $16^h\ 30^m$, after which the descent continues till the end of the registered series, which in this case unluckily breaks off at $18^h\ 30^m$, instead of being continued to the end of the term. The total observed range is 0·388.

The Beaumaris curve exhibits a singular contrast with the Edinburgh, being as smooth as the other is abruptly broken. It exhibits 4 hours of the ascent of our wave and 14 hours of the descent (the term not having been completely observed), both of a gentle character. The absolute culmination occurs at 4^h 30^m (Sept. 21), and the total observed range small (0·172 inch).

The Halifax series (which is complete, including 36 hours) exhibits the wave in progress of ascent from 5^h 30^m A.M. to 5^h 30^m P.M. of the 21st; during which 12 hours the mercury had risen 0·278 inch. At this epoch (5^h 30^m) I place the first culmination, which is, in fact, the highest of a series of low undulations. The second takes place at 8^h 30^m, but is of so flattened and obsolete a character that it hardly deserves to be called so, and is rather a low convexity interposed between the first and third, which occurs at 10^h 24^m, and is more marked, though not strongly, and at a lower level by 0·033 inch than the first. From this the curve descends very regularly to the end. Total observed range = 0·348 inch.

At Oxford the first culmination is 5^h 20^m. It is a sharp and sudden pinnacle on the upward general slope of the curve of about 0·07 inch in height on a base of 2 hours. From its subsidence at 6^h 20^m, the curve continues to rise for three hours more, till it attains a second maximum from 9^h 30^m to 10^h 30^m, which places the second culmination at 10 hours. The form of this culmination is an obtuse bulge extending over the three hours from 8^h 30^m to 11^h 30^m, and is followed by a dead level leading to a shoulder or quick slope at 15^h 30^m, and which is the last representative of our third culmination, which seems to have died out or thinned off in the progress of the wave.

At London the ascent of the wave continues till 6^h 18^m, which is the epoch of the first culmination, indicated by a great bulge in the upward slope (as at Oxford) of 0·07 inch in height and 3 hours in breadth. The *second culmination* occurs at 10^h 18^m, and is here the higher of the two, by a very trifling difference (0·007 inch), and from it the descent of the wave commences and continues uninterrupted.

Greenwich, though so near London, has the epoch of the first culmination an hour later; that of the second coincident, and also (0·007 inch) higher than the first. Both too are sharper. The descent of the curve is also somewhat more undulating than for London.

Passing from the British to the continental curves, we are at once presented with a marked contrast in respect of smoothness. The Brussels curve offers a very uniform and even convexity. The distinction of the culminations is obliterated, and an absolute maximum at 13 hours is alone observable. At this station the total range of ascent observed (during 19 hours) was 0·957 inch, and that of descent (during 17 hours) = 0·289. The curves for Alost and Louvain appear in all respects similar, but both their vertices are wanting. Passing now to Geneva, we find the ascent of the wave observed during the first 23 hours, and the descent during only the remaining 13 hours of the total series of 36 hours. The absolute culmination observed occurs at 21 hours, or at 9 A.M. of September 22, and no distinction of what have been called above the first, second and third culminations is to be made. But in the sloping ascent of the wave 10 hours antecedent to the culmination, is a very remarkable bulge, extending over the interval from 9 hours to 13 hours, which, as it appears also in the Turin and Parma curves, deserves notice. The whole ascent appears in the Geneva curve, and the minimum or trough of the preceding wave occurs at 1 hour; the total range of ascent being 0·343 inch, occupying 20 hours, being preceded by 3 hours of undecided fluctuation.

At Kremsmünster also the ascent of the wave, if not from the absolute minimum preceding, at least from a relative minimum but little elevated above it, has been observed. The true culmination took place at 21^h 25^m, and the whole curve is remarkable for its smoothness. The range in 22 hours from the projected minimum is 0·733 inch.

At Turin and Parma the absolute minimum of the preceding wave is fairly brought into view. In the former it occurs at $1^h\ 42^m$, in the latter at $1^h\ 0^m$. In both series the upward slope of the wave is broken by many subordinate fluctuations. Of these, one is evidently correspondent in the two series. It occupies at Turin the interval from $13^h\ 46^m$ to $17^h\ 46^m$, and at Parma from $15^h\ 36^m$ to $18^h\ 36^m$, forming an obtuse bulge on the slope of the curves, with a very remarkable shoulder at the end, or at the later of the two hours above indicated in each. After this each curve continues to ascend, and at $9^h\ 46^m$ at Turin and $10^h\ 36^m$ at Parma, attains a maximum which I consider as identical with that noticed at Geneva as extending from 9 hours to 13 hours, and of which the corresponding epochs, determined by comparing the middle points of each, may be stated at 11 hours and 23 hours respectively for Geneva and Parma. The Turin series unfortunately breaks off at $10^h\ 46^m$, so that a perfect identification of this feature for that station is prevented, but the general parallelism of the two curves for Turin and Parma leaves no room to doubt it. The Parma series continues till 6 P.M. on the 22nd, and continues to rise to the end, *i. e.* till $5^h\ 46^m$ M.T. at Brussels, at which epoch, however, the rise is so small that the true culmination may be considered as nearly attained, and would probably have been actually observed had the observations been continued another hour or two. Assuming this, and that the epoch of culmination for Parma was 31 hours, we have the following corresponding epochs:—

Geneva	....	11^h ±	$20^h\ 52^m$
Kremsmünster	....	....	21 25
Turin	$17^h\ 46^m$	22 ±	
Parma	18 36	23	31 ±

which give 1 hour for the time of the wave passing from Turin to Parma, and 10 hours from Geneva to Parma, while Kremsmünster is somewhat less than half an hour later than Geneva.

If we compare the culminations only, or what we must suppose to have been the culminations, at all the stations, we have as follows:—

	1st culm.	2nd culm.		Absolute culm.
Markree ..	Doubtful.	$+ 0^h\ 50^m$	Brussels........	$+13^h\ 0^m$
Edinburgh..	$-1^h\ 30^m$	+ 4 30	Geneva	+20 52
Halifax	+5 24	+ 8 24	Kremsmünster ..	+21 25
Oxford	+5 20	+ 9 50	Parma	+31 ±
London	+6 18	+10 18		
Greenwich..	+7 18	+10 18		

Assuming the first culmination to have been the true one, and that in the progress of the wave they either run together or the second thins off and is lost, we have $32^h\ 30^m$ for the time occupied in traversing the interval from Edinburgh to Parma, which in a direct line being about 950 miles, would give a mean velocity of 28 miles per hour, supposing the front of the wave to have been at right angles to this direction. But if we compare the intervals with the distances, we shall find this supposition to be inadmissible, for we find the progress of the wave to have been as follows:—

Stations.	Angle with meridian of line joining them.	Distance in statute miles.	Time of traversing it.
Edinburgh to London ...	21°	330	$7^{h}\cdot8$
London to Brussels	75	100	6 ·7
Brussels to Geneva	16	330	7 ·9
Geneva to Parma	62	220	10 ·1

These stations divide themselves into two classes; those whose directions are little inclined (the 1st and 3rd pairs) to the meridian, and those (the 2nd and 4th) whose directions are much inclined. The mean of the former gives 660^{m} in 15^{h} 7^{m}, or $42^{m}\cdot0$ per hour in a mean direction, 17° 30′ inclined to the meridian; that of the latter, 320^{m} in 16^{h} 8^{m}, or $19^{m}\cdot0$ per hour in a mean direction, 68° 30′ inclined. These data, by the resolution of a plane triangle whose sides are 42·0 and 19·0 respectively, and the included angle $= 68° 30' - 17° 30' = 51° 0'$ give 10° for the inclination of the front of the wave to the meridian, or a direction of progress from 10° N. of W. to 10° S. of E., and an actual velocity of 18·62 miles per hour.

From this, as well as from the moderate range of the observations at Markree, it would appear that in fact neither of the points which we have termed the first and second culminations were observed at that station, and that the maximum actually observed was in the nature of a protuberance on the slope of the wave analogous perhaps to what we termed the third culmination in the Edinburgh observations.

The winds of this term offer many points of interest. At Edinburgh we have mention of "strong winds" rising into "violence" at 17 hours and 21 hours from S. and S.W. In London, high wind in the morning of the 21st, from N. passing into N.N.E., the mercury being rising, whereas at the time of the violent winds at Edinburgh (at a later hour) it was falling. And it is further noticeable that in the London series a complete reversal of the direction of the wind took place before the end of the term, passing from N. by the E. to S., thence ranging to S.W., and finally settling in the S. with abated force. At Halifax also a similar reversal of direction from N.E. round by E., S.E., S.W. to W., and then settling back to S.W., was observed, as the barometer rose, culminated and fell, the strongest indication being from the W. at 20 hours, Dec. 21. At Beaumaris, the change of direction was from N.W. (very light) by W. (moderate) to W.S.W. (strong), the maximum of strength being about midnight of the 21st. The Oxford series begins with a high but subsiding wind from N., with *rising* barometer, passing round by E. to S.W., and dying into a calm with a *falling* one. At Brussels the changes were as in London, beginning from N., passing round by E. as far as N.N.W., then settling back through W. and S.W., and at the same time dying away from the time of the culmination so as to obliterate the gradations of its shift. At Geneva the series began with violent wind from S. and S.W., settling into calm as the mercury rose. At Kremsmünster, gentle from N.W. and N. during the first half of the series, calm during the last. On the whole, I am disposed to regard the winds recorded as the sequel of a more violent gale antecedent to the series observed.

The discussion of this highly interesting term has detained us long. Nevertheless it is impossible to conclude it without remarking on *the elucidation which* EVEN A SINGLE FRENCH STATION *would have afforded*, of the disconnexion of Cadiz from the others; and I cannot but add some expression of regret, that in all our accumulated observations we have none from France, the whole of whose vast territory thus interposed (with Spain and Portugal) between the line of our European stations and those of Cadiz, Gibraltar and Tangier, in great measure cripples the efficiency of these last, and reduces to a small outlying disconnected group what would otherwise have been a really important integral member of our European series. Let us hope that on any future occasion which may arise, a spirit of scientific cooperation will prevent our nearest continental neighbours from suffering their country to remain a blank in the record.

March 1838.—Markree, Edinburgh, Halifax, Cambridge, Oxford, London, Greenwich, Brussels, Kremsmünster, Cadiz.

Diurnal Oscillations.—Particularly prominent and indeed exaggerated in the curves for London, Greenwich, Oxford and Cambridge. Less conspicuous but yet discernible in that for Brussels; quite imperceptible at Markree and Edinburgh; and so far counteracted by causes of a contrary character at Halifax, that the maxima and minima throughout appear to have changed places.

The most important and indeed the only prominent feature in this term, is the comparative repose of the barometer at Brussels, and its gradually increasing disturbance in receding from that station. The Brussels curve presents a gently undulating line, with a total range of only 0·053 (of which a considerable proportion is due to diurnal oscillation), and a very trifling fall on the whole of only 0·03. London and Greenwich, on the other hand, exhibit a rising glass, with a range of 0·195. Oxford and Cambridge a more rapid ascent, the latter ranging over 0·260 inch, while at Halifax, Edinburgh and Markree the rise was very rapid, amounting in the 26 projected hours to 0·515 inch for Halifax, and 0·508 inch for Markree, at which two stations the ascent was continuous, and at Markree almost uniform, while at Edinburgh (in conformity with the barometric character of the locality) it was irregular and interrupted, ranging over 0·442 inch in 19 hours, the series being broken off before the conclusion of the term.

Departing from Brussels in other directions, we find only two very distant stations, Kremsmünster and Cadiz, both marked by considerable fluctuations. At the former we commence with a fall of 0·283, from 6 A.M. to a minimum at 6 P.M., March 21 (-6^h to $+6^h$), then a rise of 0·102 to a maximum at midnight, followed by another fall of 0·273 to a stationary point at 6 P.M. of the 22nd, a fluctuation which has nothing corresponding to it in any of the other stations. At Cadiz, a general ascent of 0·224 took place, interrupted only by two slight undulations, over the whole interval from the commencement of the series to 21 hours, Sept. 21, from which point the mercury fell (through 0·070) till the end of the series.

June 1838.—Markree, Edinburgh, Halifax, Cambridge, London, Greenwich, Alost, Brussels, Louvain, Kremsmünster, Cadiz.

The general character of the curves in this term is ascending, the diurnal oscillations not traceable, except that for Brussels, which, when cleared of their visible effect, presents a smooth and nearly straight outline, with an ascending range of 0·238 in the 26 projected hours. This smooth character (which, as we have so often had occasion to remark, belongs to this locality) is departed from even in places so little remote as Alost and Louvain, in both of which subordinate but characteristic fluctuations occur, as they do also in the London, Greenwich and Cambridge curves. At Alost, indeed, some local cause appears to have acted rather powerfully, the ascent being not only interrupted, but reversed during the three hours before midnight, in the middle of the term. At London and Greenwich a similar cause, but of less energy, seems to have been in action six hours earlier, but as traces of the same action occur simultaneously though more feebly at both Alost and Louvain, it is not possible to identify them as phases of a wave in progress.

In all the six curves enumerated, abstracting these and other more trifling inequalities, the rise is nearly at the same rate, and they form a group in decided accordance. Halifax and Edinburgh deviate much from their type, being nearly level for the first 9 or 10 hours of the 21st, and then suddenly and irregularly rising. The Markree curve also, from 0 hour to 4 hours, runs nearly level or with a slight descent, then rises by gentle successive swells (through 0·066 inch) to a slight maximum at 19 hours, gently dips to a feeble minimum at 21 hours, and then suddenly starts up with a bold rise for the remainder of the term.

Kremsmünster and Cadiz are exceptional to the general character, and for once they offer considerable agreement with each other. Both descend to a decided minimum between the 6th and 7th hour, rise to about their original level at midnight, dip to a slight minimum between 14 and 15 hours, and then rise again, the rise being sustained at Cadiz to the end, but at Kremsmünster only to 19 hours, when another fall commences. The total range at Cadiz is 0·119, at Kremsmünster 0·086, within the limits of the projected hours.

Sept. 1838.—Markree, Halifax, Bristol Channel, Cambridge, London, Greenwich, Ghent, Alost, Brussels, Louvain, Cadiz.

Markree stands in bold contrast with all the other curves of this term. It sweeps down over a range of 0·264 from a maximum at 0 hour to a minimum at 22 hours, with a very regular and free curve, while all the other curves, except Cadiz, rise with a gentle ascent. None of the diurnal movements are seen except the afternoon minimum, which is pretty conspicuous in most of them, and in some exaggerated into an extensive depression extending over the six or eight first hours of the afternoon (a feature, indeed, of no uncommon occurrence). At Brussels the forenoon maximum of the 22nd is also sensible.

The curves for Ghent and Louvain are not continued through the night. So far as they go they preserve their parallelism with that of Brussels, and offer the same eminently smooth character. At Alost this character and parallelism are again broken, precisely as in the June term, by an unexpected descent of the barometer during the three hours before midnight. All these curves, as well as those for London, Greenwich and Cambridge, begin with the depression already noticed, subsequently to which they reascend during the rest of the series attaining a higher level, the total range in all being nearly alike (0·165 inch). The curve for Cambridge, however, is materially more irregular and fluctuating.

The curves for the Bristol Channel and Halifax manifest the same generally ascending character, the former throughout; the latter up to the 18th hour, after which it redescends. Both are smooth curves and their total range nearly alike, and somewhat less than in the cases of London, Brussels, &c., viz. 0·099.

Cadiz is again exceptional. Its curve offers on the whole a slight descent, and a full and somewhat violent development of the effects of diurnal oscillation, in both maxima and both minima; beyond this no features worth remark. In this term then the movements of the European atmosphere seem to have affected three distinct and independent systems, Cadiz and Markree being types of the two exterior, and the rest of the stations of the interior system.

Dec. 1838.—Halifax, London, Greenwich, Ghent, Alost, Brussels, Louvain, Cadiz.

A generally descending, much undulated curve, for each station except Cadiz. The undulations, however, are rather numerous and small than abrupt, and (except for stations very nearly adjoining) not identifiable with each other. The Belgian range is the smallest (0·224), the London and Greenwich larger (0·304), and the Halifax greatest (0·437), supposing it continued to the end at the same mean rate at which it breaks off at $19^h\ 20^m$ (the term not being completed).

Cadiz again contrasts itself strongly with all the more northerly stations. Its curve offers a general and moderate ascent over a range of 0·132, forming a line deeply indented by the very conspicuous effect of the two diurnal minima and their intermediate maxima, which seem to have attained their full development on this occasion. In other respects there is no peculiarity. The curve too is much smoother as respects subordinate undulations than any of the others, Brussels not excepted.

Having thus discussed *seriatim* the terms of our British and European group, let us briefly review the principal results of our examination.

1. We have succeeded in tracing distinct barometric waves of many hundreds of miles in breadth over the whole extent of Europe; that is to say, at least over an area having Markree in Ireland, Cadiz in Spain, Parma in Italy, and Kremsmünster in Austria for its angular points. Not only the breadth but the direction of the front, and the velocity of progress of such waves have been clearly made out.

2. Besides these distinctly terminated waves, we have been able, if not to trace the rate and law of progress, at least to render very evident the existence of undulatory movements of much greater amplitude, so great indeed as far to exceed in dimension the area in question, and to require much more time than the duration of a term series (36 hours) for their passage over a given locality. At the same time it must be recollected that the records of every meteorologist bear ample testimony to this conclusion in the fact of long-continued rises, falls and stations (both high and low) of the barometer, continuing for many days or even weeks.

3. In Europe, Brussels is clearly entitled to be regarded as a point of comparatively gentle barometrical disturbance. Very *deep* waves, it is true, and very *extensive* ones, ride over it; but with regard to smaller ones, it may be regarded as in a certain sense a nodal point where irregularities are smoothed down, and oscillatory movement in general is more or less checked; and such movements increase in amount as we recede from Brussels as a centre, especially towards the north-west, as far as Markree.

4. The diurnal oscillations are very conspicuous in single days' observations hourly continued, this being *rather the general rule than the exception.* In particular, the afternoon minimum (4 P.M.) stands forth as a prominent feature in almost all cases where there is not some violent barometric disturbance.

5. But that to render them so conspicuous, it is by no means enough to cast up arithmetically heights above and below a mean quantity for the day. On the contrary, such a mode of proceeding has a powerful tendency to mask and conceal them. A medium curve must be struck, *liberâ manû* or *libero oculo*, so as to represent, *with the least possible amount of general curvature,* the whole day's observations; and upon this curve the diurnal fluctuations will usually appear as two principal indentations with corresponding intermediate protuberances, the protuberance and indentation immediately preceding and following the hour of noon being by far the most conspicuously and constantly visible.

6. Hanover offers barometric anomalies separating it from the Belgian type (to which latter the south of England as well as Geneva belongs). Possibly it is connected with a Scandinavian or Polish system. Edinburgh

is as remarkable for inequalities and abrupt fluctuations in its barometric changes as Brussels is for the reverse. Turin seems to be much affected by its proximity to the Alps, which gives its barometric curves frequently a very disjointed character. Between the Italian stations (Turin and Parma) and the Spanish (Cadiz, Gibraltar, Tangier) no community of character and no mutual dependence prevails. Cadiz, Gibraltar and Tangier are subject to an anomalous rise and fall of the mercury between midnight and sunrise, which interferes with and often counteracts and overcomes the regular tendency to depression in that interval, a peculiarity which is probably owing to the proximity of the great radiating surface of the African deserts. At Tangier the barometric fluctuations seem to be remarkably small. Markree is remarkable for the boldness and freedom of contour in its barometric curves, and the great range of their fluctuations compared with stations to the south-east of it.

Asiatic group.

The only stations admitting of mutual comparison are those of the Indian Peninsula, Mauritius and Van Diemen's Land being too remote. Out of the nine terms observed in any part of India also, four were only observed at one station, and neither of the remaining five at more than two, and those in only two instances the same. Under these circumstances we could not expect to trace out the propagation of waves even were any great fluctuations included in the series. It so happens, however, that in none of the terms, and in no station (except Van Diemen's Land) was this the case. The chief interest, therefore, in the discussion of this group consists in the information to be derived from the separate consideration of each station in respect of its barometric character, as to the comparative smoothness or abruptness of its variation, and the extent and law of its diurnal oscillations. And these will be found by no means devoid of interest, but on the contrary to furnish occasion for some remarks of moment.

Mauritius.—Owing to the indefatigable diligence of Captain Lloyd, late Surveyor-General of this colony, we possess nearly a complete series for this station (Sept. 1838 alone being wanting), and the observations having been made *half-hourly* in every term, we are enabled to trace more minutely on each occasion the progress of the barometric march. It appears to be extremely regular, a certain *trepidation* however frequently prevailing in the rise and fall through the diurnal phases, which contrasts very remarkably with the exceedingly smooth character of several of the curves at the Indian stations.

In all the Mauritius terms there is not one in which the diurnal maxima and minima are not fairly and strikingly developed; neither is there any one in which (laying out of consideration these phases) any material departure from a mean of the whole day is observed. Such a state of things is highly favourable for the exact determination of the elements of diurnal oscillation. I have therefore assembled in the Table (Appendix B.) the observations on all the terms reduced to 32° Fahr., and having taken the means for each hour, projected them in a curve on a scale of one inch to the hour of time, and to the hundredth of an inch barometric altitude. A straight line being then drawn from the point commencing this curve to the point terminating it will represent the *mean* march of the barometer during the 24 hours included. And our object being only to represent fluctuations above and below such a mean, this line has been taken as an abscissa (representing the level of 30·0000 inches), and from it, in the direction of the original ordinates, the altitudes were read off (by which process all that remains of casual or non-periodical movement is obviously eliminated), and thus have been obtained the following series of numbers, representing the march of the barometer during an average 24 hours at Mauritius.

Hour, M. T.	Altitude of barometer.	Hour, M. T.	Altitude of barometer.	Hour, M. T.	Altitude of barometer.	Hour, M. T.	Altitude of barometer.
	inches.		inches.		inches.		inches.
0	30·0000	6	29·9929	12	29·9859	18	30·0153
1	30·0098	7	29·9759	13	30·0007	19	30·0031
2	30·0164	8	29·9628	14	30·0137	20	29·9933
3	30·0207	9	29·9601	15	30·0237	21	29·9855
4	30·0180	10	29·9619	16	30·0291	22	29·9829
5	30·0071	11	29·9726	17	30·0248	23	29·9884
6	29·9929	12	29·9859	18	30·0153	24	30·0000

The epochs and values of the several maxima and minima, with the sums of excursions on both sides of this our medial line, are hence deduced as below:—

Epoch	3^h 12^m	....	m^1 (minimum)	29·9601
	10 0	....	M^1	30·0291
	15 48	....	m^2	29·9826
	21 15	....	M^2	30·0210

Sum of greater excursions $M^2 - m^1 = 0·0609$
Sum of lesser excursions. . $M^1 - m^2 = 0·0465$

Calcutta.—Two terms only are recorded for this station, or three if we regard the mouth of the Hoogly as identical with it. The curve for the first term (Dec. 1835) is not complete in all its hours, nevertheless such are its singular smoothness and regularity, that it admits of the diurnal elements being at once read off as follows, taking 30 inches for a mean altitude:

Epochs	3^h 0^m	9^h 54^m	15^h 48^m	21^h 24^m
Altitudes	29·945	30·030	29·979	30·054

$M^2 - m^1 = 0·109$ $\qquad$ $M^1 - m^2 = 0·051$

The term of March 1836 is somewhat disturbed by casual fluctuations, nevertheless if similarly read off, after smoothing down its angles, it gives

$M^2 - m^1 = 0·135$ $\qquad$ $M^1 - m^2 = 0·053$

The Hoogly term gives for the same sums of excursions (Dec. 1836),

$M^2 - m^1 = 0·096$ $\qquad$ $M^1 - m^2 = 0·013$

Dadoopoor.—Five terms are recorded from this station, which when projected, equalized and read off, give for the sums of the excursions due to diurnal oscillation respectively as follows:—

Term.	Sum of greater excursions.	Sum of lesser excursions.
	inch.	inch.
September 1835	0·106	0·033
March 1836	0·112	0·033
June 1836	0·138	0·013
September 1836	0·172	0·026
December 1836	0·112	0·033
Mean	0·128	0·028

Bangalore.—If we may deduce a barometrical character from only two recorded terms, this would seem to be a very peculiar station, its peculiarity consisting in an all but perfect repose of the mercury, and the absence even of any appreciable amount of diurnal oscillation. But of course no conclusion can be rested on so small a basis, nor am I in possession of any meteorological journals or recorded observations from which to institute further inquiry.

Cathmandu (Nepaul).—A very elevated station, the barometer standing at 25·3 inches. Three recorded terms only have come to hand, being those for March, June and Sept. 1837. In all the diurnal oscillations are very strongly marked. In that of March a temporary disturbance at the 6th hour P.M., arising doubtless from a misreading of 0·1 inch, mars the regularity of the curve, and if this be allowed for, the excursions run as follows:—

Term.	Sum of greatest excursions.	Sum of least excursions.
	inch.	inch.
March 1837	0·107	0·080
June 1837	0·084	0·084
September 1837	0·152	0·026
Mean	0·114	0·063

From Sikkim (? Darjding), a Subhimalayan station, we have a single term, that of March 1837. This also is a very high station, the mercury standing at 23·2. Its curve is smooth and flowing in an eminent degree, and the diurnal oscillations quite as strongly marked as in any of the Indian stations, the excursions being as follows:—

Sum of the greater 0·114; sum of the lesser 0·048.

As a contribution to our knowledge of the periodical movements of the atmosphere at high levels, these possess no small interest in proportion to the paucity of recorded observations in such circumstances.

From Hobart Town and Port Arthur we have six terms. In all of them the barometer was much and irregularly agitated; but as there is no station within comparing distance, nor have any observations from ships at sea in that region, simultaneously made, been received, it is impossible to ground any conclusion on them, the casual disturbances being too great to admit of mutual compensation in so moderate a number of terms.

In discussing the diurnal fluctuations for the several stations above, I have said nothing about the epochs, except for Mauritius. In fact, these elements are too delicate to be obtained with any degree of confidence or precision otherwise than by a very much more extensive course of observation. However, it is evident that they do not differ widely from the generally received hours (4^h, 10^h, 16^h and 22^h).

South Africa.

This group affords but three stations on land, viz. two at the Cape very near together, and the other at Bathurst, far to the eastward. There are, however, two excellent sets of observations by Captain Henning on board the Windsor, within limits of comparison. The whole number of terms observed is eleven. In all of them the barometric range was moderate. The sea observations run nearly parallel to those at the Cape, but there is no prominent feature which it is possible to seize capable of identifying any atmospheric disturbance in its progress from station to station. On the other hand, so far from any accordance subsisting between the Cape and Bathurst, a tendency to contrary movement is apparent, as will become evident by the comparison of the changes in twenty-four corresponding hours at Feldhausen and Bathurst as follows:—

Term.	Change of barometer in 24 hours at Feldhausen.	Change in 24 hours corresponding at Bathurst.
	inch.	inch.
December 1835	+0·011	−0·289
March 1836	+0·047	+0·138
June 1836	−0·041*	+0·023
September 1836	−0·211	+0·077
March 1837	+0·078	−0·157
June 1837	−0·088	+0·032
September 1837	+0·059	+0·077
December 1837	+0·058	−0·262

These are all the terms in which there are corresponding observations, and among them, three-fourths in number and all the most considerable in respect of range, are cases of contrary movement. The fact is certainly remarkable, and though it does not appear easy to refer it to any obvious cause, it seems well worthy of further inquiry.

At Bathurst the diurnal oscillations are not well made out, which is no fault of the observations or the observer, Mr. Morgan, whose care and assiduity in the making and registering of meteorological observations are quite remarkable and deserving every encomium. The contrary is the case at the Cape, as the following comparison will show:—

Term.	Sums of excursions at Feldhausen.		Sums of excursions at the observatory.	
March 1835	0·023	0·043		
June 1835	0·050	0·041		
December 1835	0·035	0·040	0·038	0·034
March 1836	0·049	0·026	0·044	0·035
June 1836	0·061	0·007	0·025	0·012
September 1836	0·049	0·044	0·042	0·051
December 1836	0·072	0·021	0·059	0·020
March 1837	0·060	0·026	0·057	0·023
June 1837	0·060	0·017	0·049	0·016
September 1837	0·057	0·013	0·057	0·017
December 1837	0·052	0·041		
Means	0·052	0·029	0·044	0·026
	0·044	0·026		
Mean of both stations	0·048	0·027		

American Group.

The United States and Canada have furnished us with thirteen term-series up to the end of 1838, observed more or less connectedly at eighteen stations,

* In this case the observatory has been compared, and there are, strictly speaking, only twenty-two hours in each series which correspond.

viz. Quebec, Montreal, Gardiner, Burlington, William's College, Albany, Boston, Providence (Rhode Island), New Haven, Middletown, Western Reserve College (Ohio), Flushing, New York, Baltimore, Cincinnati, Natchez, Washington, and St. Louis (Missouri). These stations form the main body of this group, and the only one with which it is possible to deal connectedly. In addition to these, as outlying points, five terms have been observed by Captain Owen and one by Mr. Lees at the Bahamas, and eight by Captains Beechey and Belcher at various stations along the west coast of Mexico and Guatemala down to Panama and the Gulf of Guayaquil. Had these terms been observed simultaneously it might have been possible to connect them with those of Bahama into a distinct West Indian group. But the utmost amount of simultaneous terms which can be mustered in such a group is in that of September 1836, in which a single series by Mr. Schomburgk in British Guiana is recorded, forming with those of Captain Owen and Captain Beechey a triangular group, having its angles at Guayaquil, Bahama and Ohreala, an area far too extensive, and in which, on comparison of the curves, nothing can be made out but a *want* of correspondence in every feature but the diurnal oscillations, which in all three are very conspicuously marked. A single term at Sitka, in Norfolk Sound, on the N.W. coast of America, observed by Captain Belcher, is equally incapable of being brought into comparison with every other series. Its curve is remarkably flat and even, rising with some degree of agitation towards the end of the term, while all the observations in the United States indicate a sudden and rapid fall, extending over the same hours.

The greater part of the terms of the American group of the United States and Canada have been carefully examined and discussed by Mr. Birt, whose remarks (in his own words) I shall subjoin *seriatim*, confining my own observations to points which he has not touched on, and to terms which are not included in his notes.

North American Group.

December 1835.—This term affords only two series—from Albany and Montreal, the curves of which, with a good deal of irregularity, maintain a coarse parallelism and agree in a tendency to rise at the end, which is much more decided at the latter than at the former station.

For the terms of 1836 and 1837, and March 1838, Mr. Birt has drawn out the following Table, which exhibits the barometric ranges during 27 and 37 hours respectively, with a view to the elucidation of the law of oscillation as referred to centres of greatest and least excursion. As regards this subject I may remark generally, that the stations, Montreal, Quebec and New York, but most especially the last, appear remarkable for the *smoothness* of their barometric curves as contrasted with the rest; but this is in great measure owing to the observations at these stations having been made at larger intervals, 2, 3, and often 4 hours.

I have completed the table for the remainder of 1838.

" Tabular View of the Ranges of the Barometer for 27 and 37 hourly observations at the Equinoxes and Solstices in the United States, during the years 1836, 1837, and part of 1838.

Storm Curves. March and December 1836.

March 1836.	27.	37.	December 1836.	27.	37.
Anterior or Eastern portion of storm.			New York	·837	·935
			New Haven	·966	1·007
Montreal	·241	·285	Flushing	1·039	1·042

Storm Curves. March and December 1846.

March 1836.	27.	37.
Albany	·387	·466
Flushing	·397	·447
Middletown	·426	·541
Extent of oscillation from North to South.	·185	·256
Posterior or Western portion of storm.		
Cincinnati	·334	·351

December 1836.	27.	37.
Albany	1·147	1·173
Montreal	1	
Quebec	1·613	1·613
Extent of oscillation from South to North nearly in the same meridian	·776	·678
Gardiner, Maine, 19m east of Albany	·934	1·014

"The cause of the increase of oscillation towards points of greatest oscillation in the centres of the storms is very apparent, namely the depression towards the centres of the storms producing in the surfaces of the atmosphere over them a funnel-shaped character.

"Complete range at New York during the storm of December from the shoulders only	·942
The same at Quebec	1·625
Difference of range between the two stations	·683

"June and September 1836.

June 1836.

A meridian passing through Montreal, the point of least oscillation in the series, gives the greatest increase of oscillation on the west side, rejecting Quebec, as the hours are not continuous.

	27.	37.
Quebec	·047	·078
Montreal	·050	·072
West of Montreal....		
Albany	·139	·161
Flushing	·140	·166
Baltimore	·175	·181
Extent of oscillation from North to West of South	·125	·109
East of Montreal		
William's College	·117	·117
Middletown	·133	·163
Extent of oscillation from North to East of South	·083	·091

(N.B. The observations at New York do not extend over twenty-seven complete hours.)

September 1836.	27.	37.
New Haven	·098	·162
Middletown	·101	·175
Flushing	·115	·222
*William's College	·155	·197
*Gardiner, Maine	·155	·200
Albany	·179	·232
Montreal	·273	·336
Extent of oscillation from South to North	·175	·174
New York	·067	·215
Burlington	·149	·218

The above two stations rejected as the hours are not continuous.

Cincinnati not a portion of the system..	·081	·141

The three stations, New Haven, Middletown and Flushing, are not placed above according to their relative positions; the discrepancies would probably disappear if the stations were sufficiently numerous as to allow of the observations being so arranged that the ranges might be exhibited as proceeding from a point of greatest oscillation on the radii of a circle.

* Gardiner, Maine, being considerably to the east of William's College, the similarity of range at the two stations is interesting.

" March and June 1837.

March 1837.	27.	37.
Flushing	·390	·392
Albany	·227	·274
Montreal	·195	·208
Decrease of oscillation from Flushing to Montreal	·195	·184
Flushing	·390	·392
Boston	·197	·244
Decrease of oscillation from Flushing to Boston	·193	·148

June 1837.	Fall.	Rise.
William's College	·050	·229
Middletown	·126	·302
Gardiner, Maine	·124	·135
Boston	·114	·256
Middletown	·126	·302
Flushing	·045	·266
New Haven	·100	·285
Middletown	·126	·302

The above are so arranged as to exhibit the descents and ascents of the barometer at the stations named.

It will be seen that the ascents are considerably greater than the descents, and it is probable that the summit of the barometric undulation was not attained at the respective stations at the conclusion of the observations.

" September and December 1837.

September 1837.	27.	37.
Montreal	·353	·483
William's College	·249	·439
Gardiner, Maine	·221	·336
Decrease of oscillation from Montreal	·132	·147
Boston	·252	·360
Providence	·204	·287
Decrease of oscillation from Boston	·048	·073
Middletown	·292	·381
New Haven	·277	·372
Flushing	·256	·349
New York..........	·250	·337
Decrease of oscillation from Middletown ..	·042	·044

December 1837.	27.	37.
St. Louis	·365	·483
Western R. College ..	·292	·407
New York..........	·197	·251
Flushing	·196	·265
Middletown?	·196	·255
Boston	·202	·245
Quebec	·190	·288
Gardiner, Maine	·208	·208

" March and June 1838.

March 1838.	27.	37.
{ St. Louis	·295	·295
{ Cincinnati	·253	·256
{ Western R. College	·139	·165
Decrease of oscillation from St. Louis	·156	·130
{ Montreal	·131	·261
{ Burlington (H.) ..	·176	·331
{ New York........	·364	·532
{ Flushing	·371	·514
{ New Haven	·384	·530
{ Middletown	·383	·553
{ Boston	·410	·576
{ Gardiner, Maine ..	·434	·599
Extent of oscillation from West to East..	·070	·085

June 1838. (H.)	27.	37.
Western R. College ..	·046	·087
Gardiner*	·174	·213
Boston	·175	·222
Burlington..........	·219	·219
Quebec	·339	·339

* This range supposes an erroneous reading of ·1 in one of the hours, which otherwise is quite anomalous.

"September and December 1838.

September 1838. (H.)	27.	37.
Western R. College ..	·144	·194
Flushing	·155	·192
Gardiner	·172	·234

December 1838. (H.)	27.	37.
Western R. College..	·293	·343
Flushing	·185	·203
Burlington	·171	·176
Gardiner	·079	·113

"Table of the Mean Altitudes of Barometer.

	1836.				1837.				1838.
	March.	June.	Sept.	Dec.	March.	June.	Sept.	Dec.	March.
Montreal*	29·694	29·868	29·946	Storm Curves set off from 30·000.	29·951	29·478	30·070	29·969	30·109
Albany	29·785	29·894	30·086		29·974				
William's College ...	....	29·297	29·322		....	28·795	29·398		
Middletown	29·614	29·641	29·815		....	29·250	29·962	29·634	29·875
New Haven	....	....	30·143		....	29·584	30·336	....	30·253
Flushing	29·658	29·799	30·136		29·864	29·606	30·283	29·969	30·183
New York	....	29·974	30·162		....	....	30·353	30·069	30·247
Baltimore	....	29·710							
Cincinnati	29·267	....	29·300		....	....	....	....	29·389
Western R. College..	....	....	....		....	....	....	28·762	28·799
Gardiner, Maine......	....	....	30·077		....	29·455	30·258	29·929	30·164
Boston	....	....	....		30·203	29·542	30·360	29·986	30·256
Providence	....	....	....		....	....	30·135		

March 1836.—Montreal, Albany, Flushing, Middletown, Cincinnati, Bahama, St. Catherine's Island.

(H.) Great contrast between the first mentioned four stations and the last. The curves of the former set all descend rapidly, the descent for Montreal being smooth, and undulated only by the very evident diurnal oscillations; the others are all more or less irregular, but with no distinct correspondence in the features of their irregularity. The Cincinnati curve, on the other hand, ascends rapidly but smoothly, and the diurnal phases are distinctly seen indenting its slope. In the Bahama curve the diurnal phases are extremely prominent; the sum of the greater excursions being 0·090 and of the lesser 0·069, reckoned from a line of medium slope. At St. Catherine's Island a similar remark applies, the sums of the excursions from a medial line of descent being respectively 0·090 and 0·051.

(B.) In this series the variations of the barometer are evidently due to a storm; the four stations, Montreal to Middletown, being nearly on the same meridian. The rising curve at Cincinnati doubtless arises from the western half of the storm passing over that station, while the eastern traversed the meridian of Albany. The Bahamas were entirely removed from its influence. The increase of oscillation in this case, or rather the decrease of oscillation from a central point of greatest oscillation, arises from the depression towards the centre of a rotatory storm.

June 1836.—Quebec, Montreal, William's College, Albany, Middletown, Flushing, New York, Baltimore, Bahama.

(H.) The curves for Quebec and New York are extremely remarkable for the *perfect* smoothness of their gentle upward slope, unbroken by *any undulation whatever*. Those of William's College, and especially Albany, on the contrary, are abruptly agitated, and the swells and falls coincide with the

* At Quebec, owing to the observations being for the most part at intervals of 4 hours, the means are not comparable with them.

epochs and directions of the diurnal phases. Middletown and Flushing are intermediate in character. The Baltimore curve is very regular and shows the diurnal phases very distinctly, though not extensive. At Bahama the diurnal oscillations are obliterated at the beginning and end of the series, a uniform and perfect level being maintained from 14 hours to 24 hours.

(B.) This group, with the exception of the Bahamas, presents a series of curves evidently forming a system of oscillations, the area extending over 21′ of longitude and 7° 31′ of latitude; this area, on which most of the American stations are situated, appears from the succeeding observations to have presented the most complete systems of oscillations.

(B.) In proceeding from north to south there appears to be some irregularity in the increase, but by arranging the stations as in the Table*, it will be seen that there is a gradual increase on each side of the meridian of Montreal.

September 1836.—Montreal, Burlington, Albany, Gardiner, William's College, New York, Flushing, Middletown, New Haven, Cincinnati, Bahama, Ohreala, Guayaquil.

(H.) All the curves of the first nine stations are on the whole nearly level, with undecided fluctuations, referable chiefly to diurnal oscillation, until about the 20th or 21st hour of September 21, when they begin to dip downwards. The Cincinnati curve runs level, in three distinct stages of level, beginning and terminating at about 0·07 inch higher than its middle portion; this, however, is merely an effect of the periodical oscillations, in which the nightly maximum and morning minimum are blended and obliterated.

The smoothest curve in this term is that of Gardiner. Middletown and New Haven are also smooth. Albany is most broken (chiefly in the evening), which seems to be its general character. Of the West Indian curves I have already spoken.

(B.) This sheet exhibits a well-marked and very interesting group, occupying nearly the same geographical area already noticed, namely from New York on the west to Gardiner, Maine on the east, the northern and southern boundaries being respectively Montreal and Flushing. The general similarity of these curves is very apparent also, the double curve indicating a diurnal oscillation at each of the stations; the increase of oscillation is also distinctly marked proceeding towards the north.

(B.) The intermediate elevations and depressions offer very interesting matter for remark, the greatest development of them is at Flushing. At Montreal, the station of greatest oscillation, they have nearly disappeared. The intermediate curves are generally apparent when the oscillation is less than ·100. At Cincinnati, to which the system did not extend, the extent of oscillation was ·081 for 27 and ·141 for 37 observations; here the curve was simple.

(B.) The falls at the latter portions of the curves are much steeper than those at the anterior portions; the falls at New York and Flushing are less steep than the others.

December 1836.—Quebec, Montreal, Albany, Flushing, New Haven, New York, Gardiner, Bahama.

(H.) This term exhibits finely the barometric features and local progress of a storm. The barometric ranges will be found in the general table. The greatest intensity of the storm seems to have prevailed at Quebec, Montreal,

* *Vide* the Synoptic Table at the commencement of the American group.

and New York. The greatest depression of the barometer at the several stations, where the minimum was within the limits of the term, took place at the hours following of December 21 (mean time at each station).

Quebec......	9 A.M. ::	Flushing	0 Noon.
Montreal	9 A.M.	New Haven	1 P.M.
New York ..	10 A.M. ::	Gardiner	5 P.M.
Albany......	11 A.M.		

At Montreal and Quebec the rise of the barometer from its greatest depression was singularly steady and unbroken by any convulsive movements. At Quebec, indeed, this might be ascribed to the system of 4-hourly observation pursued, but not so for Montreal, where the observations were hourly. At New Haven, New York, and Flushing also, the same remark applies with almost equal force; this places in a strong light the peculiarity of Albany, to which I have before alluded, viz. the broken and abrupt character of its curves; for in this instance its curve is most remarkably zigzaged over the whole of its upward slope.

The following Table, exhibiting the movements of the barometer at Quebec and New York, *before* as well as during the storm, has been constructed by Mr. Birt from its records.

(B.) Table of Barometric Altitudes at New York and Quebec during the storm of December 20, 21 and 22, 1836, reduced to a temperature of 32° Fahr.

Day.	Hour.	New York.	Quebec.	Day.	Hour.	New York.	Quebec.
19.	10 P.M.	30·689		21.	Noon.	....	28·762
20.	6 A.M.	·600			2 P.M.	·779	
	10 A.M.	·627			3 P.M.	....	29·082
	Noon.	....	30·387		6 P.M.	30·036	·311
	2 P.M.	·445			9 P.M.	....	·467
	3 P.M.	....	·314		10 P.M.	·275	
	6 P.M.	·342	·257		Midnight.	....	·726
	9 P.M.	....	·168	22.	3 A.M.	....	·932
	10 P.M.	·183			6 A.M.	·521	30·135
	Midnight.	....	·080		9 A.M.	....	·295
21.	3 A.M.	....	29·809		10 A.M.	·616	
	6 A.M.	29·723	·525		Noon.	....	·375
	9 A.M.	....	·292		2 P.M.	·570	
	10 A.M.	·685			6 P.M.	·620	

(H.) This storm was not felt at Bahama, the curve for which during this term exhibits a state of tranquillity, the diurnal phases only being observable and very well developed.

(B.) Mr. Redfield remarks, that "the period allotted for the observations includes, on this occasion, a portion of an extensive inland storm of marked character and rapid development;" at nearly all the stations the latter portion only was observed; the progressive character of the storm is very apparent from the curves. In consequence of the very extensive range of the barometer the scale is half of that which is employed for the other projections, namely ·75 of the larger divisions = ·1.

(B.) The observations at New York and Quebec include, at intervals of 3 and 4 hours, the almost complete barometric development of the storm. I have accordingly projected the two curves on an additional sheet scale 1· of the larger divisions = ·1. The immense and rapid fall at Quebec, at the middle of the storm, as compared with the phænomena presented at New York at the same time, is interesting; also the shoulders at New York at 10 A.M. of the 20th, and at 10 A.M. of the 22nd, exhibiting a wave at the circumference of the funnel.

(B.) In comparing the ranges, I have taken the range at New York from the shoulders only, as the observations at Quebec do not include them.

March 1837.—Boston, Flushing, Albany, Montreal, Bahama, Magnetic Island.

(H.) The observations at Magnetic Island break off at midnight of the 21st. All the other curves, Bahama included, descend, but with different rapidities and degrees of irregularity.

(H.) The Boston curve is very smooth (hourly observations). It continues nearly level till 11 P.M., then dips gracefully to a minimum at 25 hours (1 hour, March 22nd). Its range within the 26 projected hours is 0·192.

(H.) The Flushing and Albany curves are much and abruptly broken, but exhibit no correspondence in their zigzags. Both attain minima at the 25th hour. Their ranges, as above, are 0·387 and 0·225.

(H.) The Montreal curve exhibits the diurnal oscillations superposed on a regular line of descending slope, the evening maximums being somewhat broken. In other respects the curve is very smooth. The *general* slope is rectilinear and less steep than in the others, viz. *at the average rate of* 0·145 in 24 hours.

(H.) The Bahama curve is still less steep, sloping at the average rate of 0·13 in 24 hours. Its diurnal fluctuations, though very visible, are not normally developed.

(B.) Among the curves on this sheet that were obtained from the eastern portion of the United States, there is a general similarity. It is probable they formed part of a system of oscillation having a point of greatest oscillation. The curve obtained at Flushing exhibits the greatest oscillation, but as there are no observations south or south-west of this station it cannot be considered as *the point* of greatest oscillation. Observations from the south-east and south on the Atlantic would have been very interesting at this term.

June 1837.—Quebec, Montreal, Burlington, Gardiner, Boston, Middletown, New Haven, William's College, Flushing, Natchez, Washington (incomplete).

(H.) The curves of this term may be classed in two systems, the first consisting of those of Quebec, Montreal and Burlington; the second, of all the rest. The character of the first class is a general tendency to ascent, interrupted somewhat irregularly by the diurnal phases, in which the morning minimum is anticipated by two or three hours, a particular, however, which cannot be traced at Quebec, the observations having been discontinued from midnight till 6 A.M.

The other stations may be divided into subclasses, graduating into one another; those which exhibit a strong maximum in the earlier and a strong minimum in the later hours of the projected series (Gardiner and Boston); those in which this maximum merges in the maximum preceding the noon of June 21, and is separated from the strong characteristic minimum by 8 or 10 hours of level, the said minimum itself beginning at an earlier epoch (at about 2 or 3 A.M., as Middletown, New Haven, William's College); and lastly, those in which no such characteristic *maximum* can at all be traced, and in which the minimum assumes the character of a flat and gentle depression, coming on progressively earlier and earlier in the series (as at Flushing, Natchez and Washington).

(H.) In all these but Natchez and Washington, the curve, after the characteristic minimum, rises very rapidly, but at Natchez this rise does not take place. At Washington the series terminates at 7 P.M. on the 21st, so that it remains undecided what course the curve takes in the later hours.

(B.) This sheet exhibits a well-marked and prominent group of similar curves, which occupies an extent of longitude from Flushing to Gardiner, Maine = 19 minutes. The depression of the curve at each station is one of the most interesting features. By inspecting the Table of Ranges it will be seen that the greatest oscillation was observed at Middletown, and it appears probable that the oscillations decreased on radii from this point. I have endeavoured to exhibit this by terminating each set of ranges with the range at Middletown. It is, however, a matter of regret that the observations were not more numerous by which this interesting point might have been more strikingly illustrated. The descents as well as the ascents of the curves increase towards Middletown, with the exception of the curve at Gardiner: this curve appears to partake of the character of the curve obtained at Montreal in its anterior portion. The curve at Montreal evidently does not belong to this system.

(B.) The order of time in which the lowest altitudes of the barometer at the several stations were observed, is as under:—

Flushing	21st	8 P.M.	
New Haven	22nd	1 A.M.	
William's College....	22nd	2 A.M.	
Middletown	22nd	5 A.M.?	(series broken.)
Boston	22nd	6 A.M.	
Gardiner	22nd	10 A.M.	

(B.) The curves to the north of this group, namely, those obtained at Quebec and Montreal, are decidedly different, and that obtained at Natchez evidently belongs to a different system. The oscillation at this station being under ·100, exhibits the diurnal oscillation.

(H.) I incline to regard both Natchez and Washington as belonging to this system, or at least on the verge of it; and if so, the minima there observed (though very feebly marked) ought to be added to the above Table, thus

Natchez............	21st	8 P.M.
Washington	21st	6 P.M.

Sept. 1887.—Providence, Boston, Gardiner, Burlington, Flushing, New York, New Haven, Middletown, William's College, Montreal.—Sitka. Also a few hours of the end of the term at Quebec.

(H.) Sitka is entirely disconnected and has already been sufficiently characterized. All the other stations exhibit descending curves, and in all, the final rate of descent is much more rapid than the initial, so that they obviously belong to one system.

(H.) The curves in this term are generally *smooth*, especially those for Providence, Boston, Flushing, New York and New Haven. Traces of the diurnal oscillations prevail in most of them, though a good deal distorted in their epochs. The Montreal is the only curve which (abstraction made of these) offers much undulation. In this the descent is suspended during all the interval from 7 P.M. Sept. 21 to 2 A.M. Sept. 22, and replaced by a gentle ascent, after which the rapid descent begins. Beyond this I have nothing to add to Mr. Birt's remarks which follow.

(B.) This group, which extends only from New York 1^m west to Gardiner, Maine 19^m east of Albany, exhibits a general agreement among the curves, all of them descending. The group, however, may be divided into minor portions, in which different features are well marked. The three flattest curves, especially in their anterior portions, were obtained at Providence, Boston and Gardiner. The curves at New York, New Haven and Middletown, also agree tolerably well with each other, especially the two last, New York agreeing more with Flushing, which connects as it were the two minor groups. William's College is nearly similar to the Middletown group, and the curve at Montreal differs from the others mostly in the depression at 6 and 7 P.M. Gardiner, Maine presents the nearest similarity to it.

(B.) The curves in this sheet present a different phænomenon, inasmuch as the increase of oscillation does not appear to be regular; but when we separate the curves into groups, as above, we perceive it. Flushing appears to be an exception. By including Flushing in the Middletown group, we have stations exhibiting smaller ranges between those presenting larger; William's College between Montreal and the New Haven or Middletown group; Providence between Middletown and Boston; and Gardiner nearly in the same parallel with William's College. This exhibition of smaller ranges in connection with the minor groups of curves is highly interesting, exhibiting, as the Middletown group does, the increase of oscillation towards that station.

(B.) This group is perhaps one of the most interesting, particularly as relates to the extent of oscillation at the several stations. By referring to the Table of ranges for June and September 1836, it will be seen that the oscillations at William's College were less than those at the neighbouring station, Albany. The mean altitude of the barometer is also less at William's College than at Albany.

(B.) On this occasion (Sept. 1837) the altitude of the barometer was greater than on any other at all the stations except at Montreal, which exhibited the greatest oscillation. By taking a similar view of these as of the June observations, there appears to be three centres of oscillation, namely, Montreal, Boston and Middletown. The oscillations are accordingly arranged in this manner in the Table.

Dec. 1837.—St. Louis, Western Reserve College, New York, Flushing, Quebec, Montreal, Middletown, Burlington, Boston, Gardiner, Bahama, St. Blas.

(H.) All the curves for the above stations, in the order in which they are here arranged, down to Boston inclusive, begin by descending to a minimum, in the case of New York only coinciding in epoch (4 P.M.) with the afternoon minimum; in all the others anticipating of it by 1, 2, or 3 hours, the times being as follow:—

Burlington....	1 P.M. 21st.	Boston	2 P.M.
Middletown ..	1 P.M.	Western Reserve Coll. ..	2 P.M.
St. Louis	1 P.M.	Flushing..............	3 P.M.
Quebec	2 P.M.	New York	4 P.M.

From this minimum they all rise, with more or less subordinate undulation, and with degrees of rapidity corresponding to the order of succession of the stations above set down. In the Boston, Burlington, New York and Flushing curves, the diurnal oscillations (and especially the maximum of the forenoon of the 22nd) are strongly indented on the upward slope.

(H.) The curve for Gardiner is peculiar, and indicates some local disturbance. In place of the minimum with which the others commence being of a concave or basin-shaped form, this is deeply cuspidated, being formed by a bold convex sweep, plunging down to an abrupt point at 5 hours mean time, whence it immediately rises and slopes up in three distinct stages to the end. The St. Blas curve has no resemblance to any of the rest, but offers a fine specimen of diurnal oscillation boldly developed.

(B.) The curves on this sheet exhibit a greater extent of area over which similar affections of the atmosphere were observed than any of the others. From Western Reserve College (31^m west of Albany) to Boston (11^m east of the same station), a group of similar curves is apparent; the depressions occurring about 3 P.M., and the apices about 10 A.M.: 42^m of longitude appear to be the extent of this group.

(B.) The ranges of the barometer from New York to Boston are nearly similar (rejecting the 5 P.M. observation at Middletown, which appears to be in error). For twenty-seven observations, Boston, the easternmost station, exhibits the greatest range. For thirty-seven observations, Flushing exhibits the greatest, the difference between this station and Boston being ·022.

(B.) The curve at Gardiner, Maine, while exhibiting to a certain extent similar features to the curves westward, does not belong exclusively to the system. The range for twenty-seven observations is rather more than that at Boston, but considerably less for thirty-seven. The anterior portion of the curve as far as 5 P.M. is decidedly different from the preceding curves, and the continuous portion of it after 1 P.M. also differs very materially.

(B.) The curve at St. Louis, while it generally agrees with the curves of the Maine group during the hours projected on the sheet, differs from them during the afternoon hours of the 22nd, being somewhat similar to Gardiner, Maine.

March 1838.—Western Reserve College, Cincinnati, St. Louis, Montreal, Burlington, New York, Flushing, Newhaven, Middletown, Boston, Gardiner; — Realejo.

(H.) The Realejo curve is disconnected with the rest and incomplete; the observations breaking off before the conclusion of the terms. Its general form is a flat concavity, with its minimum at 5 P.M., Mar. 21.

The rest of the stations may be classed as follows;—

A.	B.	C.
Gardiner.	Burlington.	St. Louis.
Boston.	Montreal.	Cincinnati.
Middletown.		Western Reserve College.
New Haven.		
Flushing.		
New York.		

Group A. consists of eastern stations. Its curves rise steadily from the first commencement of the observations at daybreak of the 21st to a sub-culmination at about 1 A.M. of the 22nd (13 hours, 21st), whence they slightly dip to the morning minimum about 15 hours or 16 hours, and rising again, attain their absolute culmination at or about the regular epoch of the forenoon maximum, viz. 22 hours (10 A.M., Mar. 22nd). They all run closely parallel with exception of Boston and Gardiner, which manifest some irregularities and abruptnesses.

(H.) Group B. of northern stations show a kind of transition state of the curves. The true culmination comes on much earlier (at midnight between the 21st and 22nd), and the upward slope is much less steep, and shows signs of a minimum having been attained shortly before the commencement of the term.

(H.) In the group C. this minimum comes clearly within the range of the observations, but at very different hours, viz. for

St. Louis	at 3 P.M.,	M. T. at Station,		21st.
Cincinnati	„ 6 „	„ „	„	„
Western Reserve College	„ 3 A.M.,	„ „	„	22nd.

(H.) The minimum in question for St. Louis, falling nearly on the regular epoch of the afternoon minimum of the diurnal oscillations, is reinforced by it, and is very decided and well rounded. At Cincinnati this has not been the case; and a kind of struggle of tendencies seems to have taken place, marked by a double depression and abrupt intermediate elevation. At Western Reserve College the minimum we are tracing falling nearly on the gentler depression of the regular morning minimum, and being accompanied with less general movement of the mercury, forms a long flat depression, ending in a gentle and continued upward slope extending beyond the limits of the term.

(B.) This sheet presents three well-marked and distinct groups of curves in the United States. The most prominent is that of the eastern states, extending from New York to Gardiner, Maine: here the apices occur about the same hour, but the minimum altitudes of the barometer were not observed, the first observation of each series being the lowest.

(B.) The next group, namely, Western Reserve College, Cincinnati and St Louis, increases towards the west. The curves do not, however, present that similarity noticed in the eastern curves: the marked difference between the curves at Western Reserve College and New York indicates that the western limit of the eastern group passed between these stations. Again, the curve at Montreal being decidedly different from all the others, shows that the eastern group did not extend so far north. Observations are wanted to define the eastern limits of this group.

(B.) Upon reviewing the projections it appears that the area included within a line passing from Baltimore north-east towards Quebec, inclosing Albany, from thence south-east to Gardiner, and thence south-west along the coast, passing New York and joining itself at Baltimore, and upon which are situated the following stations, Baltimore, Albany, William's College, Burlington, Montreal, Quebec, Gardiner, Maine, Boston, Providence, R. I., Middletown, New Haven, Flushing, L. I., and New York, is characterized by the most complete systems of oscillation afforded by the group, the curves obtained at the above-mentioned stations more or less agreeing with each other. There are two principal lines of these stations, one from north to south, the other from west to east, or rather from south-west to north-east.

North to South.	South-west to North-east.
Montreal.	Baltimore.
Burlington.	New York.
Albany.	Flushing.
William's College.	New Haven.
New York.	Middletown.
Flushing.	Providence.
	Boston.
	Gardiner, Maine.

(B.) In order to examine more particularly the nature of the increase of oscillation, it will probably be requisite to obtain stations in other parts of this area should future observations be undertaken.

(B.) With respect to the increase of oscillation, the following questions have suggested themselves:—Do the oscillations increase from a *single point* of *least oscillation*? or do they decrease from a *single point* of *greatest oscillation*? The observations appear to indicate that they decrease from a single point of greatest oscillation, particularly those of June 1837. On this occasion the changes of the wind indicated the passage of a body of air in a state of rotatory motion, although it appears difficult to suppose that this body was of a cylindrical form, as the greatest depression of the barometer at each of the stations occurred with a north-west wind, consequently the centre of rotation must have been north-east of the station at the time: perhaps some other form, a body the horizontal section of which is an ellipse, for instance, may explain this. Upon the whole, the small number of stations over so large an area, and these occurring on two lines only, is a matter of much regret, as we can only at present obtain a glance at the affections of the atmosphere over this vast space. Probably if the stations were more numerous, the character of the decrease of oscillation from a point of greatest oscillation would be distinctly marked.

June 1838.—Quebec, Burlington, Gardiner, Boston;—Western Reserve College.

(H.) The first four stations in their order form a group in which the progressive modifications of a fluctuation of considerable extent may be clearly traced. It is best developed at Quebec (where fortunately the observations of this term are for the most part hourly, or at furthest two-hourly), and consists of a complete wave, with its lowest depression and culmination fully in view, and both very decided and regularly formed, the epochs being as below:—

Lowest depression ..	5 P.M., 21st M.T., at Station.
Culmination	9 A.M., 22nd „ „ „
Amplitude	0·355 in.

At Burlington the wave is flatter, and somewhat less regular. Epochs and amplitude as below:—

Lowest depression............	7 P.M., 21st.
Culmination	0 Noon, 22nd.
Amplitude of oscillation	0·219 in.

At Gardiner the wave is still more flattened, and the culmination protracted and rendered indistinct, so as to make it doubtful whether it falls fairly within the series, or whether another rise commences:—

Lowest depression	7 P.M., 21st.
Culmination	2 „ 22nd.
Amplitude	0·100 in.

Lastly, at Boston the wave is wholly obliterated, and we have a gently-descending curve undulated only by the regular diurnal oscillations.

The curve of Western Reserve College offers a level, unbroken except by the regular maxima and minima, which are however far from conspicuous in their development.

Sept. 1838.—Gardiner, Flushing, Western Reserve College.

(H.) Western Reserve College, on the moderately descending slope of its curve, exhibits the diurnal oscillations strongly but rather irregularly. Both minima, however, and both maxima are unequivocally made out.

The Flushing and Gardiner curves both slope downwards nearly at an equal rate; the former very smoothly and gradually, the latter by four successive stages with levels between. In the former the descent is continued to the end of the term of 36 hours; in the latter a minimum is attained, and the last two hours of the series exhibit the commencement of a rise. The terms are too few for available comparison.

Dec. 1838.—Gardiner, Burlington, Flushing, Western Reserve College; —Estero Real.

(H.) The Gardiner curve exhibits a series of small and gentle undulations, superposed on a gentle and even convexity, culminating about 3 A.M., Dec. 22. In that for Burlington, with the same general aspect, the convexity is more considerable and its culmination occurs earlier, viz at 8 P.M., Dec. 21. Before the end of the series, however, a point of contrary flexure occurs, and a minimum is attained at 2 P.M., Dec. 22, which is not the case at Gardiner. At Flushing the swell, the contrary flexure and the minimum are all more decided, giving a distinct culmination at 10 P.M., 21st, and point of greater depression at 3 P.M., 22nd.

(H.) At Western Reserve College the whole series of thirty-six hours offers only one great concavity, the lowest point occurring at 4 A.M. of the 22nd. But we have no intermediate observations to connect this with the minima observed in the later hours of the Burlington and Flushing series, and the general aspect of the curves, as well as the much greater fluctuation, renders such connexion improbable.

(H.) Estero Real is of course quite out of connexion with the above stations, but its curve is remarkable as exhibiting the finest specimen of the diurnal fluctuations of any we have yet passed in review. Its epochs and sums of excursions are as follow in mean time:

m^1	M^1	m^2	M^2
4^h	10^h	15^h	$21\frac{1}{2}^h$.

Sum of greater excursions.. $(M^2 - m^1) = 0{\cdot}168$.
Sum of lesser excursions .. $(M^1 - m^2) = 0{\cdot}037$.

Concluding Remarks (H.).—Having now discussed in their order the observations of each term, and stated the conclusions which have presented themselves in the course of their examination, it may be expected that I should express some opinion as to the utility of prosecuting a similar series of observations more extensively, and on the objects chiefly to be aimed at in so doing. And here I must first observe, that supposing any such continued series set on foot, it would be highly desirable, by previous communication and concert, to secure a multitude of cooperators on chosen lines of connexion, so as to obtain, at least for those stations, more regularly continued series of terms than those which are comprised in our list, and to narrow in some degree the field of inquiry by limiting it (as I have been compelled to do) to some distinct point of meteorology, such as the tracing of atmospheric waves and the determination of the coefficients of the diurnal periods. To the latter point the *hourly* system of observation *alone* is applicable, and monthly series (on the 21st of each month) of such observations from a vast number of stations in which absolutely nothing else was set down than the hourly march of the barometer for twenty-five consecutive hours (so as to *begin and conclude the twenty-four hours with an observation*), would in itself, if continued for a few years, leave nothing to be desired on this important head. I need not insist on each observer reducing his own observations. The time is arrived in meteorology when *unreduced* observations (at least barometrical ones) can no longer be tolerated, and must henceforward (except at very peculiar stations) be considered as not having been made. The tables for the purpose are in every one's possession who can be considered competent to use the barometer scientifically; and if the correction be applied *at once* at the time of reading off, the trouble is so subdivided as to be reduced almost to nothing. It should, however, be remembered by all who may undertake such observations, that unless made *at each hour of the twenty-five and at the exact hours*, a series loses much of its value; and if two or more hours be deficient, it is hardly worth using, as its comparability with others ceases. We have seen, from the instance of Mauritius (and the remark applies to most inter-tropical stations), that from twelve to sixteen unexceptionable series of the kind in question suffice to afford a perfect solution of the problem of the diurnal movements when mean quantities only are concerned; and in all probability three or four years' continuance of *monthly* terms would lead to a knowledge of the annually periodic variations in their coefficients. For *such* an object, dew-points, clouds, temperatures (other than needed to reduce the barometer to the freezing standard), and even winds, *might* be pretermitted, though I am far from *advising* their neglect.

As regards, however, the exceedingly interesting subject of the atmospheric waves, it is right I should observe that, without setting on foot (except with special views and in highly civilized localities) *any* express series of observations, but simply by comparing and reducing what already stand on record, —or even by projecting them unreduced, where great undulations only are to be traced,—the way lies open to most valuable conclusions. The fluctuations we have been able to trace by projecting the term observations, are those only whose total duration of rise and fall is comprised within or does not much exceed the twenty-four or thirty-six hours over which the term extends. But these are by no means those which either theoretically or indeed practically speaking are to be regarded as most important. I have the pleasure to lay before the Section specimens of barometric projections by Mr. Birt, laid down from his own observation, in which the interval between two successive maxima of pressure occupied in the one case seventeen days without any intervening maximum; in another, a similar period *with* two subordinate maxima interposed; and another where a beautifully symmetrical wave of an extremely remarkable character occupied thirteen days for its complete rise and fall. [See curves designated as "Barometric Waves," respectively annexed. Plates I. and II.]

For such objects (as before observed) we need not travel beyond existing records. In the records of our own magnetic and meteorological observatories, and those which stand in correspondence with them throughout the world, we have ample materials; and when dealing with undulations of such extent, it is by no means a visionary speculation to consider the possibility of tracing them over the *whole* of our globe; nay, perhaps of obtaining evidence of their performing, tide-like, two or more revolutions round its surface. And although the pressure of other avocations will (unfortunately perhaps for myself) entirely preclude my taking any further personal share in this most interesting inquiry, I am authorized by Mr. Birt to state, that should it be the pleasure of the British Association to intrust the subject to his inquiries by appointing him a committee for that purpose, he is prepared to pursue it if provided with a moderate grant to clear unavoidable expense.

Before concluding this report it may not be irrelevant to add a few words on the subject of the winds generally as connected with barometrical movements. In the mode in which I have been accustomed to consider the subject, the winds may be divided into two classes,—winds of translation and winds of oscillation; nearly in the way in which the movements of the ocean may be divided into oceanic currents and tide-streams, and these again (regarded as the result of oscillatory movements) may be referred to the general laws which regulate the molecular movements of water in contact with the bottom of the sea, when under the influence of undulatory agitation. The trade-winds and greater aerial currents of a similar character, to which the name of monsoons is given, are winds of translation. They have a distinct barometrical origin, in the diminution of pressure in approaching the equator, caused by the expansion of the equatorial atmosphere and the overflowing of the upper strata outwards towards the poles. But this cause is not oscillatory but permanent. Monsoons also arise in the same way; from local heating and cooling periodically renewed, it is true; but in long periods of six months in duration, so as to give rise to steady currents. With such winds the present research has little connexion, except in so far as their powerful influence mixes with and masks the effect of the other class of winds,—those which arise from barometric *oscillation*, and which are connected with such oscillation in a more direct and intimate manner. The oscillations themselves perhaps take their rise in local and temporary causes prevailing over great areas simultaneously, the principal no doubt depending on the prevalence of cloud or clear sky, rain, or dryness over great tracts for several days or weeks in succession. But once produced, and an extensive atmospheric undulation once propagated, a wind or system of winds dependent on such undulation necessarily arises also. Every wave-like movement in a fluid (see Weber's 'Wellenlehre') consists of two distinct things, *an advancing form* and a *molecular movement*, which latter consists in a two-fold motion of each particle, vertical and horizontal. Laying aside at present the consideration of the vertical movement (which belongs only to the strata not in contact with the ground, and with which probably many interesting particulars respecting the formation and dispersion of clouds, the precipitation of rain, and the generation of lightning are connected), those strata which are in immediate contact with the ground, in obedience to the general laws of fluid movement, have their vertical movement zero and their horizontal a maximum, and for the most part (in periodical waves) alternately progressive and retrogressive.

Now, the *advancing form* is indicated to us by the barometer, the *molecular movement* by the wind, and between these two phænomena there subsists of necessity a close and purely dynamical connexion. And it would be no small meteorological discovery if, by the study of the characters and progress of barometrical fluctuations, we could either make out any law of the greater ones which would enable us even roughly to predict them, or any peculiarity in their physiognomy by which we could recognize them in their earlier stages, as by this we might possibly be led to the prediction of great storms.

Everybody must have remarked the sudden reversion of wind which often accompanies short and brisk storms accompanied with thunder and lightning (I do not now speak of the great so-called "revolving" gales). This phænomenon I consider as quite a case in point. But the horizontal motion of a particle of air in contact with the earth's surface need not be a straight line or even a returning curve. It would be the former only in the case of a straight, cylindriform wave once passing or periodically repeated; it would be the latter in the case of an oscillatory movement revolving round a node in the way in which Mr. Whewell has proved the tide-wave to do round certain definite points in the Channel. Now it *is* a fact, which has of late been a good deal insisted upon, viz. that in certain stations the winds do revolve in one uniform direction. The vane, for example, at Greenwich (as I am informed by the Astronomer Royal) makes five revolutions per annum in one uniform direction. May not this phænomenon, which, I confess, offers otherwise some difficulty of conception, be in effect an indication of some such atmospheric node, where a line perpendicular to the strata of the atmosphere may be regarded as describing a conical surface round the true vertical? If it be true (as the discussion of the term-observations has led to suspect) that Brussels is in effect such a nodal point, the examination in this view of its "Wind-Rose" would be interesting.

On the subject of "revolving" storms I am not fully prepared to speak; but there is certainly one point of view in which some of the principal of their phænomena would seem capable of explanation in this way of conceiving winds of oscillation, and in which they would become traced up, not to "funnel-shaped revolving depressions" in the nature of waterspouts, but simply to the crossing of two large long waves running in different directions thus:— where A A' A'' represent the progress of one wave, B B' B'' that of the other, and t t' t'' that of the tornado made by their intersection. The way in which a rotary movement in an ellipse or circle, or in some other partly oval and partly rectilinear figure, may result from the combination of two rectilinear movements of advance and recess, will easily be understood by the analogy of the circular and elliptic polarization of light, where rectilinear movements of the æthereal molecules are conceived to be similarly combined. Some features in such storms are strongly in harmony with this view, viz. the fact that in them the direction of the wind at a given locality never makes more than one rotation, and not always that; and that in the central line of the storm's progress there is a simple and sudden reversal of direction. On the other hand, it must not be concealed that some features militate against it; for instance, the fact that such gales are stated always to "revolve" in one direction, whereas on this view of their origin the changes of wind ought to be in opposite directions on opposite sides of the medial line. But for the present it must suffice to have pointed out a mode of considering the subject of at least certain sorts of winds which, being in the nature of a *vera causa*, resulting from dynamical considerations perfectly general and indefeasible, cannot be without some influence, the only question being that of amount.

Fifty-five pounds of the original grant of 100*l.* have been expended: should the Association order the printing of this report, a portion of the remainder may be applied to cover the expense of engraving or lithographing the curves above noticed and accompanying this report, expressing Mr. Birt's observed waves. The publication of all the projected term-curves would incur a more serious additional expense without a corresponding benefit. In furnishing the basis of the above discussions they have performed their office, though as records they should be carefully preserved.

(Signed) J. F. W. HERSCHEL.

ERRATA.

Page 72, line 44, *for* Dec. *read* Sept.
Page 74, lines 36, 38, 39, *for* Sept. *read* Dec.
Page 75, lines 2, 43, *for* Sept. *read* Dec.

Appendix A.—Containing a Synopsis of the Stations and Terms.

	Longitude.	Latitude.	Observer or Authority.	1835.				1836.				1837.				1838.			
European Group.																			
Edinburgh (Physico. Math. Soc.)	3° 11′ W.	55° 55′ N.	Committee of Society	.	.	.	.	.	.	.	D	M	.	S	D	M	J	.	.
Markree, Sligo, Ireland	8 30 W.	54 8 N.	E. Cooper, Esq., M.P.	.	.	S	D	M	J	S	D	M	J	S	D	M	J	S	D
Halifax, Yorkshire	1 50 W.	53 46 N.	J. W. Waterhouse, Esq.	.	.	.	.	.	J	S	D	M	J	S	D	M	J	S	D
Beaumaris, Anglesey	4 3 W.	53 16 W.	Captain Beechey, R.N.	.	.	.	.	.	.	.	.	.	.	.	D	.	.	.	.
Bristol Channel	......	......	Captain Beechey, R.N.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	S	.
Limerick, Ireland	8 32 W.	52 41 N.	Major Sabine, R.A.	.	.	.	.	M	J	S	.	.	.	.	.	.	.	.	.
Cambridge (Observatory)	0 10 E.	52 12 N.	Professor Challis, &c.	.	.	.	.	.	.	.	.	.	.	S	.	M	J	S	.
Oxford (Radcliffe Observatory)	1 15 W.	51 44 N.	Professor Rigaud	.	.	.	.	.	J	S	D	.	J	.	D	M	.	.	.
Blackheath Road	0 0	51 28 N.	— Henry, Esq.	.	.	.	.	M	J	S	D	.	.	.	.	.	.	.	.
Greenwich Observatory	0 0	51 27 N.	Messrs. Airy, Simms, Ellis	.	.	S	.	M	J	S	D	M	J	S	D	M	J	S	D
Greenwich Royal Hospital School	0 0	51 27 N.	— Riddle, Esq.	.	.	S	.	.	.	.	.	.	.	.	.	.	.	.	.
London (Royal Society)	0 7 W.	51 31 N.	J. D. Roberton, Esq.	.	J	S	D	M	J	S	D	M	J	S	D	M	J	S	D
Ashurst, Surrey	......	......	R. Snow, Esq.	.	.	.	.	.	.	.	D	.	J	S	.	.	.	.	.
Hanover	9 48 E.	52 20 N.	Dr. Heeren	.	.	.	.	.	J	S	D	M	J	S	.	.	.	.	.
Ghent	3 45 E.	51 4 N.	......	.	.	.	.	.	.	.	.	.	.	.	.	.	.	S	D
Alost	4 5 E.	50 55 N.	Professor Stärke	.	.	.	.	.	.	.	.	.	.	.	D	.	J	S	D
Maestricht	5 41 E.	50 49 N.	MM. Reimsdyk and Ryke	.	.	.	.	M	.	.	.	.	.	.	.	.	.	.	.
Brussels (Observatory)	4 20 E.	50 47 N.	M. Quetelet	.	J	S	D	M	J	S	D	M	J	S	D	M	J	S	D
Drachenfels, near Bonn	7 1 E.	50 42 N.	Professor Forbes	.	.	.	.	.	.	.	.	.	J	.	.	.	.	.	.
Geneva (Observatory)	6 6 E.	46 11 N.	M. Müller	.	.	S	D	M	J	S	D	M	J	S	D	.	.	.	.
St. Jeanne de Maurienne	6 21 E.	45 19 N.	The Bishop of Maurienne	.	.	.	.	.	.	.	D	M	.	.	.	.	.	.	.
Kremsmünster	14 8 E.	......	M. Koller	.	.	.	.	.	.	.	D	M	J	S	D	M	J	.	.
Turin (Observatory)	7 41 E.	45 3 N.	Chevalier Plana	.	.	.	.	.	J	S	D	M	J	S	D	.	.	.	.
Parma	10 10 E.	44 45 N.	M. Colla	.	.	.	.	.	.	.	.	.	.	.	D	.	.	.	.
Cadiz (Observatory)	6 16 E.	36 32 N.	D. J. Sanchez Cerquero	.	.	.	.	M	J	S	D	M	J	S	D	M	J	S	D
Gibraltar	5 20 E.	36 8 N.	— Cornwell, Esq.	.	.	.	D	M	J	S	D	M	J	.	.	.	.	.	.
Tangier	5 50 W.	35 48 N.	Drummond Hay, Esq.	.	.	.	.	M	.	.	.	M	J	.	.	.	.	.	.
Asiatic Group.																			
Calcutta	88 25 E.	22 35 N.	Mr. Barrow	.	.	.	D	M	.	.	.	.	.	.	.	.	.	.	.
Dadoopoor	......	......	Colonel Colvin and Mons. Durand	.	.	S	D	M	J	S	D	.	.	.	.	.	.	.	.
Bangalore	77 40 E.	13 5 N.	......	.	.	.	.	.	J	S	.	.	.	.	.	.	.	.	.
Cathmandoo (Nepaul)	85 5 E.	27 45 N.	A. Campbell, Esq.	.	.	.	.	.	.	.	.	M	J	S	.	.	.	.	.
Sikkim (Subhimalaya)	88 10 E.	27 5 N.	Dr. Chapman	.	.	.	.	.	.	.	.	M	J	S	.	.	.	.	.
Hoogly River (ship Meriton)	88 5 E.	22 0 N.	Captain Montrion	.	.	.	.	.	.	.	D	.	.	.	.	.	.	.	.
At sea (ship Fairlie)	94 E.	39 S.	Captain Burnett	.	.	.	.	.	.	.	D	.	.	.	.	.	.	.	.
Port Louis, Mauritius	57 20 E.	20 0 S.	Captain Lloyd, Surveyor-General	.	J	S	D	M	J	S	D	M	J	S	D	M	J	.	D
Hobart Town, Port Arthur, Van Diemen's Land	147 20 E.	42 40 S.	Mr. Lempriere	.	.	.	.	.	.	.	.	M	J	S	D	M	J	.	.

Appendix A. (Continued.)

	Longitude.	Latitude.	Observer or Authority.	1835.				1836.				1837.				1838.			
South African Group.																			
Royal Observatory near Cape Town	18° 29′ E.	33° 56′ S.	T. Maclear, Esq., Astronomer Royal	M	J	.	D	M	J	S	D	M	J	S	.				
Feldhausen, Wynberg	18 29 E.	34 0 S.	Sir J. Herschel	M	J	.	D	M	J	S	D	M	J	S	D				
Bathurst			N. Morgan, Esq., Staff Assist. Surg.	.	.	.	D	M	J	S	.	M	J	S	D				
Ship Windsor, at Sea	1 34 W.	18 47 S.	Lieutenant Henning, R.N.	.	.	.	.	M	.	.	.	.	.	.	.				
Ship Windsor, at Sea	15 13 E.	39 9 S.	Lieutenant Henning, R.N.	.	.	.	.	.	.	S	.	.	.	.	.				
American Group.																			
Sitka, Norfolk Sound	135 20 W.	57 2 N.	Captain Belcher	.	.	.	.	.	.	.	.	.	.	S	.	.	.	.	.
Quebec, Canada	71 20 W.	46 55 N.	Mr. Daintry	.	.	.	.	.	J	.	D	.	J	S	D	.	J	.	.
Montreal, Canada	73 22 W.	45 30 N.	Mr. M^cCord	.	.	.	D	M	J	S	D	M	J	S	D	M	.	.	.
Gardiner, Maine	70 ± W.	44 10 N.	Mr. Gardiner	.	.	.	.	.	.	S	D	.	J	S	D	M	J	S	D
Burlington University, Vermont			Messrs. Benedict and Chaney	.	.	.	.	.	.	S	.	.	J	S	D	M	J	.	D
William's College			Dr. Eamons	.	.	.	.	.	J	S	.	.	J	S	.	.	.	.	.
Albany (Institute)	73 47 W.	42 39 N.	H. Webster, Esq., Secretary	.	.	.	D	M	J	S	D	M	.	.	.	.	.	.	.
Boston	71 4 W.	42 21 N.	R. T. Paine, Esq.	.	.	.	.	.	.	.	.	M	J	S	D	M	J	.	.
Providence, R. I. (Brown University)	71 25 W.	41 50 N.	A. Caswell, Esq.	.	.	.	.	.	.	.	.	.	.	S	.	.	.	.	.
Newhaven, Connecticut	72 57 W.	41 18 N.	— Herrick, Esq.	.	.	.	.	.	.	S	D	.	J	S	.	M	.	.	.
Middletown, Wesleyan University	72 39 W.	41 35 N.	A. W. Smith, Esq.	.	.	.	.	M	J	S	.	.	J	S	D	M	.	.	.
Western Reserve College, Ohio	81 30 W.	41 3 N.	Professor Loomis	.	.	.	.	.	.	.	.	.	.	.	D	M	J	S	D
Flushing	73 44 W.	40 45 N.	Dr. Gill	.	.	.	.	M	J	S	D	M	J	S	D	M	.	S	D
New York	74 12 W.	40 48 N.	Professor Redfield	.	.	.	.	.	J	S	D	.	.	S	D	M	.	.	.
Baltimore	76 40 W.	39 18 N.		.	.	.	.	.	J	.	.	.	.	.	.	.	.	.	.
Cincinnati, Ohio (Medical College)	84 25 W.	39 9 N.	Professor Locke, M.D.	.	.	.	.	M	.	S	.	.	.	.	.	M	.	.	.
Natchez, Missouri	91 25 W.	31 34 N.	— Tooley, Esq.	.	.	.	.	.	.	.	.	.	J	.	.	.	.	.	.
Washington (Jefferson College)	91 20 W.	31 37 N.	Professor Forsby and Lady	.	.	.	.	.	.	.	.	.	J	.	.	.	.	.	.
St. Louis, Missouri	90 0 W.	38 45 N.		.	.	.	.	.	.	.	.	.	.	.	D	M	.	.	.
Bahamas, New Providence	77 30 W.	25 0 N.	— Lees, Esq., Chief Justice	.	.	.	.	.	.	.	.	.	.	.	D	.	.	.	.
Bahamas, H.M.S. Thunder	73 79″ W.	26 29° N.	Captain Owen	.	.	.	.	M	J	S	D	M	.	.	.	.	.	.	.
St. Catherine's Island (H.M.S. Sulphur)			Captain Beechey	.	.	.	.	M	.	.	.	.	.	.	.	.	.	.	.
Magnetic Island (H.M.S. Sulphur, and on shore)	81 47 W.	8 4 N.	Captain Belcher	.	.	.	.	.	.	.	.	M	.	.	.	.	.	.	.
Gulf of Guayaquil (H.M.S. Sulphur)	80 ± W.	3 ± S.	Captain Beechey	.	.	.	.	.	.	S	.	.	.	.	.	.	.	.	.
Realejo (H.M.S. Sulphur, and on shore)	87 10 W.	12 30 N.	Captain Belcher	.	.	.	.	.	.	.	.	.	.	.	.	M	.	.	.
Estero Real (H.M.S. Sulphur)	90 ± W.	13 ± N.	Captain Belcher	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	D
San Blas (Palm Island)			Captain Belcher	.	.	.	.	.	.	.	.	.	.	.	D				
Ohreala, British Guiana	56 54 W.	5 8 N.	— Schomburgk, Esq.	.	.	.	.	.	.	S	.	.	.	.	.	.	.	.	.

APPENDIX B.—Barometric altitudes observed at Mauritius during the first twenty-four hours of the recorded terms reduced to 32° Fahr., with a view to the deduction of the elements of the diurnal oscillations.

Term Observed.		A.M.						Noon.	P.M.											Midnight.	A.M.					
		6	7	8	9	10	11		1	2	3	4	5	6	7	8	9	10	11		1	2	3	4	5	6
June 1835	in. 30	105	109	125	135	124	109	095	072	052	046	052	058	092	117	116	124	132	135	125	126	109	102	102	104	106
September 1835	30	190	195	209	213	212	204	197	166	152	151	156	194	202	210	227	227	227	219	203	206	202	187	172	198	205
December 1835	30	011	008	012	023	022	011	998	993	974	967	961	974	975	991	996	011	011	978	974	940	950	934	929	945	947
March 1836	29	920	931	942	956	940	940	920	915	910	905	905	920	925	955	981	987	986	960	976	981	979	961	953	980	991
June 1836	30	104	105	122	132	130	121	104	096	059	054	056	091	111	100	101	121	122	112	102	102	097	091	097	107	112
September 1836	30	110	120	122	122	127	107	096	049	041	029	046	046	052	077	102	097	097	097	092	057	047	042	042	037	047
December 1836	30	033	048	050	043	043	043	027	022	013	992	979	991	016	033	043	052	078	076	076	048	030	010	035	043	070
March 1837	29	972	975	992	986	982	977	945	920	900	899	899	902	907	922	944	973	969	969	953	929	917	907	892	890	903
June 1837	30	212	214	216	218	218	212	177	150	150	145	142	158	165	172	187	212	207	207	202	177	152	147	138	132	147
September 1837	30	099	130	138	122	135	103	098	087	058	083	089	099	107	106	126	142	145	134	139	119	109	114	099	114	127
December 1837	30	048	096	073	078	041	033	012	002	987	972	974	979	998	025	030	035	061	056	031	016	993	983	985	991	016
March 1838	29	979	974	973	986	984	967	966	944	914	929	922	927	930	957	965	955	961	961	963	929	938	938	925	920	922
June 1838	30	211	213	222	242	240	214	217	207	202	212	217	217	222	228	247	250	254	256	253	243	247	238	218	223	228
December 1838	29	995	605	904	904	914	914	909	889	894	889	880	875	902	912	917	922	927	923	917	903	885	875	865	870	888
Mean of 14 months ...	30	0635	0729	0786	0829	0794	0682	0543	0365	0219	0195	0199	0308	0431	0575	0701	0790	0841	0774	0719	0554	0468	0378	0343	0396	0506

Report of the Committee appointed by the British Association for Experiments on Steam-Engines. Members of the Committee:—EATON HODGKINSON, *Esq., F.R.S.*; J. ENYS, *Esq.*; Rev. Professor MOSELEY, *M.A. F.R.S.*; *and* Professor WILLIAM POLE.

YOUR Committee, in reporting the progress of the experiments entrusted to their care, have the pleasure of stating that they have succeeded in accomplishing the principal object which has engaged their attention during the past year; namely, to ascertain by actual experiment the velocity of the piston of a single-acting Cornish pumping-engine, at all points of its stroke.

Unfortunately, however, from delays and accidents, arising from causes inherent in the delicate nature of the operations required and the machine used, there has not been yet time to obtain the data and work out the calculations necessary for comparing the results of experiment with those of theory, and by that means eliciting the useful information which it is hoped this comparison will offer to practical science.

The velocity-measuring machine constructed by Breguet of Paris, under the kindly proffered direction of M. Morin, was received a few months ago. It is on the same principle as those with which the beautiful experiments of M. Morin on friction were made, and which are described minutely in the works of this writer (Nouvelles Expériences sur le Frottement, or Déscription des Appareils Chronométriques). These may be referred to for a full and complete explanation of the construction and action of the machine, but the principle of it may be briefly explained as follows.

A circular disc, covered with card or paper, is made to revolve with a *uniform* motion by means of clockwork regulated by air vanes. Upon this disc, a revolving pencil, whose motion is caused by and corresponds with that of the body whose *variable* velocity is to be measured, describes a curved line: and from this curve, which results from a combination of the *variable* with the *uniform* motion, the velocity may be easily ascertained by processes and formulæ adapted to the purpose.

This beautiful and ingenious contrivance, by which spaces described in the 10,000dth part of a second may be easily discerned, is the invention of M. Poncelet, carried into execution by M. Morin.

On examining the machine, it was found necessary to make some few repairs of injuries it had received in carriage, and also some alterations to fit it for the particular purpose it was proposed to apply it to. These were done by Mr. Holtzapffel.

The instrument, when put in order, was first tried at King's College, a variable motion being given by a small carriage made to descend an inclined plane. The correspondence of the velocity shown by the machine, with that deduced by the known laws of dynamics, was such as to give great confidence in its accuracy; and after a few minor alterations suggested by frequent trials, it was removed to the East London Water Works, Old Ford, and, by the kind permission of Mr. Wicksteed, the engineer, was attached to the Cornish engine at work there. This was considered a very favourable engine to experiment upon, inasmuch as the constants involved in its working had been so accurately ascertained by Mr. Wicksteed in his previous experiments, and so amply confirmed by the long trial of the constant indicator upon it by your Committee during the years 1841 and 1842.

After several preparatory trials and adjustments, some diagrams were taken on the 8th of August, and the velocities calculated from these have been expressed in the form of geometrical curves, whose abscissæ represent the spaces passed over by the piston of the engine, and whose ordinates indicate the corresponding velocities at the different points of the stroke.

The velocity of the *in-door*, or descending stroke of the piston, is taken from the mean of three experiments, differing very little from each other. The velocity begins from zero, accelerating as the piston descends, until at about four feet of the stroke it attains a maximum of about 10·4 feet per second. This is the point where the pressure of the steam in the cylinder has, by expanding, become exactly equal to the resistance opposed to the motion of the piston; and from this point the velocity gradually decreases as the steam becomes more attenuated, until the piston is gradually brought to rest by the exhaustion or expenditure of the whole of the *work* accumulated in the moving mass (in the shape of *vis viva*) during the early part of the stroke, while the steam power exceeded the resistance.

The velocity of the *out-door*, or pumping stroke, is much less than that of the former, the greatest velocity being only about 3·8 ft. per sec.

Your Committee are still engaged in the necessary investigations connected with these experiments, and hope to be able to furnish a more complete report in time for publication in the Transactions of the Association*.

It is desirable to take this opportunity of acknowledging that the thanks of the Committee are particularly due to Mr. Wicksteed and his sub-engineer, Mr. Price, for the accommodation rendered at Old Ford; to Mr. Cowper, of King's College, for his kind and able assistance in the experiments; to Mr. Holtzapffel and Mr. Timme for the attention paid to the repairs and adjustments of the machine; and to Mr. Penn, of Greenwich, for the loan of an excellent indicator.

H. MOSELEY.

London, 14th August, 1843. WILLIAM POLE (Reporter).

Report of a Committee, consisting of Mr. H. E. STRICKLAND, Prof. DAUBENY, Prof. HENSLOW *and* Prof. LINDLEY, *appointed to continue their Experiments on the Vitality of Seeds.*

THE Committee have to report, that a considerable addition has been this year made to the collection of seeds deposited at the Botanic Garden, Oxford. As, however, it is very desirable that the seeds of a great variety of plants should be collected, so that at least one representative of every natural family may be obtained, they beg to solicit further contributions of seeds (addressed to Dr. Daubeny, Botanic Garden, Oxford), from any persons who may be interested in the inquiry. The seeds should of course be of good quality, and the dates when gathered should be noted, in the mode explained in our last year's report.

The Committee have expended 1*l.* 14*s.* in printing circulars, 2*l.* 10*s.* 3*d.* in the purchase of seeds, and 9*l.* 6*s.* 8*d.* in expenses connected with the conduct and registration of the experiments. They estimate that a grant of 15*l.* for the ensuing year would suffice for the pursuance of the inquiry.

During the autumn of 1842, seeds of one species of eighty-five genera of plants were collected in addition to those noticed in the report submitted in 1842. These have been in every instance preserved according to the mode specified in the resolutions of the Committee appointed to investigate the same, and are deposited in a room devoted exclusively to them in the Oxford Botanic Garden.

Of the eighty-five additional kinds of seeds,

34 were gathered in the Oxford Botanic Garden,
21 from the Horticultural Society's Garden at Chiswick,
1 from H. E. Strickland, Esq.,
1 from Colonel P. Yorke,
1 from Thomas Hankey, Esq., favoured by Prof. Lindley,
85—27 purchased of Mr. Charlwood, Covent Garden, London.

A portion of the preceding kinds of seeds were sown in May 1843, in the Oxford Botanic Garden, the garden of the Horticultural Society at Chiswick, and also in the Cambridge Botanic Garden. These seeds were all gathered in 1842, with the exception of Nos. 1 and 85. The result of the experiments made in each garden is shown in the following table.

* This Report has been completed, but at too late a period for insertion in the present volume of the Transactions.—Ed.

	Names.	No. sown at each garden.	Oxford. No. vegetated.	Time of vegetating, in days.	Remarks.
1.	Seeds from an ancient Egyptian shoe, found at Thebes; presented by Col. Yorke, 1842.	8			Sown on the 24th of May, with the exception of those which required bottom heat, on a bed of soil, in a cold frame, the light being on only during night-time, to protect the germinating seeds from snails, slugs, &c. The seeds were all sown in shallow drills of uniform depth, and the time of germinating registered when the seed-leaves first appeared above the surface of the soil. Of Nos. 15 and 19 many seeds are still perfect.
2.	Aconitum Napellus	100			
3.	Adonis autumnalis	50	33	18	
4.	Amaranthus caudatus	100	81	4	
5.	Anagallis arvensis	100	23	11	
6.	Buffonia annua	100	47	4	
7.	Buphthalmum cordifolium	100	52	7	
8.	Bupleurum rotundifolium	100	4	19	
9.	Conium maculatum	100	80	11	
10.	Cytisus Laburnum	50	14	5	
11.	Dipsacus laciniatus	50	39	8	
12.	Elsholtzia cristata	100	83	4	
13.	Erysimum Peroffskianum	100	81	4	
14.	Helianthus indicus	25	24	5	
15.	Heracleum elegans	50	1	20	
16.	Hyoscyamus niger	100	3	30	
17.	Iberis umbellata	100	100	5	
18.	Iris sibirica	50			
19.	Lathyrus heterophyllus	50	26	21	
20.	Leonurus Cardiaca	100	66	8	
21.	Malcomia maritima	100	87	3	
22.	Malope grandiflora	100	54	4	
23.	Momordica Elaterium	25			
24.	Nepeta Cataria	100	14	16	
25.	Nicandra physaloides	100	86	6	
26.	Nigella nana	50	39	11	
27.	Orobus niger	50			
28.	Stenactis speciosa	100	34	5	
29.	Tetragonolobus purpureus	25	22	6	
30.	Trigonella fœnum-græcum	50	45	3	
31.	Tropæolum majus	25	17	7	Sown on hot-bed (heat very gentle, as in other cases).
32.	Cucurbita ovifera *var.*	15	13	6	
33.	Gilia achilleæfolia	100			
34.	Capsicum	25	20	9	On hot-bed.
35.	Medicago maculata	100	46	14	
36.	Calandrinia speciosa	100	39	3	
37.	Callichroa platyglossa	100	58	4	
38.	Collomia coccinea	100	48	7	
39.	Coreopsis atrosanguinea	100	78	6	
40.	Cotoneaster rotundifolia	20	...	...	Not yet vegetated.
41.	Cratægus macrantha	50	...	...	Ditto.
42.	——— punctata	50	...	...	Ditto.
43.	Cynoglossum glochidatum	100	16	9	

	Cambridge*.				Chiswick.		
	No. vegetated.	Time of vegetating, in days.	Remarks.		No. vegetated.	Time of vegetating, in days.	Remarks.
1.	...	...	These were carefully tried with Mays (from catacombs of Peru) in three pots, watered respectively with water, solution of nitrate of soda, and chlorine *weak*, but none germinated.	1.	...	...	Sown May 28th.
2.				2.			
3.	26	21	Largest portion germinated after forty-four days; not yet ceased?	3.	31	29	Very healthy.
4.	68	6		4.	61	28	Weakly.
5.	48	13		5.			
6.	49	8		6.	13	44	Weak.
7.	15	11		7.	10	46	Very unequal.
8.	19	17		8.	8	45	Very weakly.
9.	31	16		9.	49	34	Good.
10.	24	14		10.	42	30	Good.
11.	11	14		11.	13	28	Very strong.
12.	18	9		12.			
13.	69	8		13.	84	23	Strong.
14.	26 !	6		14.	21	32	Good.
15.				15.			
16.	2	37	Probably more will come up.	16.			
17.	82	8		17.	98	12	Very strong.
18.				18.			
19.	14	50	Ditto.	19.	4	45	Very weak.
20.	54	11		20.	45	29	Good.
21.	86	4		21.	79	11	Very strong.
22.	34	5		22.	70	34	Good.
23.				23.			
24.				24.			
25.	71	11		25.	86	24	Good.
26.	45	13		26.	26	34	Good.
27.				27.			
28.				28.	79	42	Very unequal.
29.	21	13		29.	15	27	Very strong.
30.	40	4		30.	37	19	Very strong.
31.	22	12		31.	25	32	Good.
32.	12	12		32.	10	20	Good.
33.				33.			
34.	15	18	Perhaps more will come up.	34.	21	38	Good.
35.	20	8		35.	10	20	Very healthy.
36.	51	4		36.	27	29	Weakly.
37.	34	4		37.			
38.	45	8		38.	42	40	Strong.
39.	7	25		39.			
40.			[* Sown June 2nd, 1843. Professor Henslow remarks that this year, and also last, the seeds were not sown at Cambridge, but at Hitcham, Suffolk, and watched by himself.]	40.			
41.				41.			
42.				42.			
43.	4	19		43.	5	42	Weak.

	Names.	No. sown at each garden.	Oxford. No. vegetated.	Time of vegetating, in days.	Remarks.
44.	Digitalis lutea	100	95	9	
45.	Eutoca viscida	100	72	7	
46.	Glaucium rubrum.	100	5	16	
47.	Godetia Lindleyana	100	37	7	
48.	Gladiolus psittacinus	100	28	25	
49.	Impatiens glanduligera	50	...	...	On hot-bed.
50.	Lupinus succulentus	100	54	3	
51.	Nolana atriplicifolia	100	14	5	
52.	Oxyura chrysanthemoides	100	18	5	
53.	Papaver amœnum	100	50	8	
54.	Phacelia tanacetifolia	100	34	4	
55.	Potentilla nepalensis	100	49	10	
56.	Sphenogyne speciosa	100	45	7	
57.	Acacia pseud-acacia	100	14	9	Some seeds still perfect.
58.	Alstrœmeria pelegrina	20	6	20	On hot-bed.
59.	Betula alba	200			
60.	Carpinus Betula	100			
61.	Catalpa cordifolia	50	10	16	
62.	Cercis canadensis	50	4	20	Many seeds still perfect.
63.	Cerinthe major	50	45	7	
64.	Cichorium Endivia *var.*	150	80	5	
65.	Cobæa scandens	6	...	...	On hot-bed.
66.	Cuphea procumbens	50	17	7	Ditto.
67.	Dolichos lignosus	25	21	9	
68.	Galinsogea trilobata	100	69	9	
69.	Ilex Aquifolium	100	...	...	Not yet vegetated.
70.	Juniperus communis	100	...	...	Ditto.
71.	Liriodendron Tulipiferum	50	1	83	
72.	Loasa nitida	100	67	8	On hot-bed.
73.	Magnolia sp.	15			
74.	Martynia proboscidea	20	8	19	Ditto.
75.	Mesembryanthemum crystallinum	100	45	7	Ditto.
76.	Mirabilis Jalapa	25	9	7	Ditto.
77.	Morus nigra	100	41	32	
78.	Ricinus communis	15	7	10	Ditto.
79.	Rudbeckia amplexicaulis	150	10	26	
80.	Scorpiurus sulcata	25	21	7	
81.	Tetragonia expansa	15	15	12	
82.	Ulex europæa	100	20	12	Some seeds still perfect.
83.	Quercus Robur	10	...	...	Acorns rotten.
84.	Phœnix Dactylifera	3	2	45	On hot-bed.
85.	Melon seed from Persia ?, 1817	6	...	...	Ditto. (Made up to Nov. 25.)

	Cambridge.				Chiswick.		
	No. vegetated.	Time of vegetating, in days.	Remarks.		No. vegetated.	Time of vegetating, in days.	Remarks.
44.	26	25		44.	92	39	Very equal.
45.	24	11		45.	72	30	Very unequal.
46.	1	?		46.	4	45	Very weak.
47.	21	6		47.	81	32	Very healthy.
48.	6	50	Probably more will come up.	48.	8	31	Very weak.
49.				49.			
50.	63	5		50.	98	28	Very strong.
51.	56	7		51.	50	30	Good.
52.	22	9		52.	14	42	Weakly.
53.	39	9		53.	90	20	Strong.
54.	74	4		54.	23	12	Very healthy.
55.				55.			
56.	18	12		56.	94	25	Very healthy.
57.	17	16	Ditto.	57.			
58.	13	27		58.			
59.				59.			
60.				60.			
61.				61.	1	41	Very weak.
62.	5	26	Ditto.	62.			
63.	42	12		63.	24	27	Very equal.
64.	81	5		64.	67	17	Good.
65.				65.			
66.	8	15		66.	21	29	Weakly.
67.	20	43	Ditto.	67.	23	45	Strong.
68.	25	16		68.			
69.				69.			
70.				70.			
71.				71.			
72.	59	11	Several much later.	72.	27	30	Very strong.
73.				73.			
74.	8	23	Most much later.	74.	12	38	Good.
75.	8	16		75.			
76.	7	13		76.	10	42	Strong.
77.	15	23	Probably more will come up.	77.	26	43	Good.
78.	8	19		78.	6	29	Very strong.
79.				79.			
80.	23	11	Mostly much later.	80.	15	18	Good.
81.	14	16		81.	9	28	Good.
82.	16	17		82.			
83.				83.			
84.				84.			
85.				85.			
			(Made up to August 4.)				

W. H. Baxter, Curator.

H. E. Strickland.
C. B. Daubeny.

Report of a Series of Observations on the Tides of the Frith of Forth and the East Coast of Scotland. By J. S. Russell, *Esq.*

These observations extended over several seasons, and no complete report had been yet presented, as the observations of each former season had only shown the necessity of further extending the observations. The observations of the first season had shown the existence of certain anomalous tides, which had not formerly been accurately examined, and proved that these anomalies were more extensive than was at first conceived. Next season the observations were more widely extended, so as to include many adjacent places, to which the same anomalies were traced, and thus the general nature and extent of the phænomena were determined with accuracy and precision, and reported to the last meeting. But it was found that great differences of opinion existed with reference to the cause of these ascertained phænomena, which rendered it obvious that the observations required to be extended still further in time and extent, in order conclusively to settle the questions which had arisen out of the former inquiries. This last series, from its extent and completeness, had now been so fully examined and discussed, as to afford ample means of deciding on the nature of the phænomena, and determining their origin. Simultaneous observations had been made at nearly twenty stations on the eastern coast, from Newcastle and Shields to Inverness; and as many as 2000 observations in a day registered and discussed. The results of these were exhibited in the tables and diagrams accompanying the report. And the result of the whole had been to elucidate in a remarkable manner, the mechanism which propagates along our shores and rivers the great ocean-wave which carries from one place to another the successive phænomena of the tides, in such a manner as could not have been attained by any system of observation less extensive than that which had been adopted.

It is pretty generally known that the phænomena of the tides, with reference to their generating cause, the influence of the mass of the sun and of the moon, in the various relations of distance and direction of these luminaries, have recently been examined with great success, in a series of researches carried on first by Mr. Lubbock, and then by Mr. Whewell, partly with the co-operation of this Association. By means of their labours we are now enabled to predict with unlooked-for accuracy, the time of high water and the height of the tide in many of the harbours of Great Britain. But many of the local phænomena of tides remained unaccounted for, and these had been the object of a special series of researches, of which the present formed a part, the object being to determine in what way the conformation of the shores, and of the bottom of the sea, and the forms of the channels of rivers and friths affect the phænomena of the tidal-wave. The rivers Dee and Clyde had been formerly examined with this view. To these were now added the Forth, the Tay, and the Tyne, and the northern shores of the German Ocean. [The author then described the general character of the coast, and pointed out the peculiarities of position and form which render the Frith of Forth so remarkable a feature of it.]

The manner in which these observations were conducted is not the usual one, of noting down simply the hour at which high water occurs, and then the hour of low water, along with the height at which the water stands at these times; such a method had been found quite inadequate to the purposes for which such observations are required; and indeed Mr. Russell thought it of importance that all tide observations should, if possible, be made in the manner he was now about to describe, especially all tide observations made for scientific purposes. He had adopted this method in all his observations, those published formerly in the Transactions being on a similar plan, but in this case it had been more fully carried out, and found of greater importance than in former cases. This plan was to carry on simultaneously at the places examined, a series of continuous observations every five minutes night and day, by successive observers, without intermission, for the period of a month, or of several months, as might be required. Printed forms were sent to all the stations, and in them the observer simply noted down every five minutes the height of the tide on a graduated scale placed before him. Every day at noon all these papers were sent by post to the central station, and immediately on their arrival the papers of the different stations were compared and their observations laid down on paper, so as to give a graphical representation to the eye of all the observations, by means of which they were at once verified and compared with great facility; and accuracy of observation was by this means made very certain, as carelessness or incorrectness in the observations was at once manifest to the eye.

These tide-waves were represented to the eye in the following way. A horizontal line is divided into equal parts, which represent time or hours, thus,—VI, VII, VIII, IX, X, XI, XII, I, &c.; and these spaces are again subdivided into twelfth parts of an hour; a scale of feet is placed vertically, and numbered 1, 2, 3, 4, 5, &c.; then the observations are taken, and if is found that at VI o'clock the water stood at 0, and then was low water; at VII the water had risen to 1 foot, and a mark is made one foot high above the hour VII; at VIII a mark is made at the corresponding height of $2\frac{1}{2}$ feet; at IX a mark is placed above it to the corresponding height. When this has been done for every hour and also for every five minutes, these points form a line, which exhibits the form of the tide-wave as it passed that station on the day of observation; in this way are laid down on the same paper all the observations of the same day at the different stations.

From the examination of the form of these tide-waves thus laid down, certain characters of the tide-wave peculiar to each locality had been discovered. As in the former observations of the Clyde and the Dee, so in this series it had been found that the form and dimensions of a channel produce important changes on the form of the tide-wave. Where the sea was deep and the shore open and abrupt, the tide-wave was symmetrical, and of the form predicted by Laplace, when he says that in rising and falling the water covers in equal times equal arcs of a vertical circle. This is the form of the ocean tide-wave; but on approaching a shallow shore and travelling along a shelving coast, the tide-wave undergoes two changes; its summit becomes displaced forwards in time, its horizontal chords become dislocated, and the wave ceases to be symmetrical. This peculiar dislocation and displacement are characteristic of a littoral tide, and in the case of running streams, the currents still further affect the tide-wave, and give to it a peculiar distortion characteristic of fluvial tides. To these were further added the exaggeration and elevation of the tide by means of narrow channels. All these phænomena were fully proved by the present series of observations.

The author also considers it to have been fully established, by the observations on the Frith of Forth, that there exists on the eastern coast satisfactory evidence of the presence of a second tide-wave in that part of the German Ocean, and that the southern tide-wave, a day older than the northern tide-wave, sensibly affects the phænomena of that part of the coast. To this he attributes the double tides of the Frith of Forth, the nature of which he fully explained. Regarding these double tides various theories had been formed; and there were various ways in which such tides might happen, whenever tide-waves arrive by different paths in different times. But this kind of double tide was in this case only to be explained by the method he had adopted, which removed the difficulties in which the subject had formerly been involved.

He then proceeded to explain the mode of discussion which had been adopted. It was the semi-diurnal inequality, so accurately examined by Mr. Whewell, which enabled us to decide on the ages of two tides. If the two tides which appeared together presented opposite inequalities both in time and in height, regularly alternating, varying with the moon's declination, disappearing with it and reappearing with it, and following it regularly without regard to other simultaneous changes of a different period, then it becomes plain that no other inference could be drawn than that he had mentioned; and when further, he had proceeded to treat these tides as compounded of two successive tides, one due to a transit $12^h 24^m$ later than the other, and had used for this purpose two simple river tides superimposed at a distance in time corresponding to that at which the northern and southern tides could enter the Frith, he had obtained a close representation of the double tides of the Frith of Forth; when these two methods of examination ended in the same conclusion, he conceived that it had attained a very high degree of probability.

By means of these observations tide tables had been formed which were designed to afford a more accurate means of predicting the local tides of the east coast of Scotland than any we now possessed.

The author of the report took occasion to express the deep regret with which he appeared as the *only* representative of this Committee, having been deprived of the valuable services of his coadjutor by the lamented death of Sir John Robison, a zealous promoter of science and a valuable member of the British Association.

Notice of a Report of the Committee on the Form of Ships. By JOHN SCOTT RUSSELL, *Esq.*

THIS report was voluminous, containing the reductions of a large number of experiments, and about 20,000 observations, made on more than 100 vessels of different forms, accurate drawings of all of which, on a large working scale, were laid on the table. It is the hope of the Committee that this report may be published in order to give the public all the benefit which accurate knowledge on this point was likely to convey. The present abstract does not therefore enter fully into the details of their voluminous results, but is confined to a general account of the objects which this Committee had in view, the methods of inquiry which they had adopted, and a few of the more general conclusions to which they had been conducted.

It had long been the reproach of science that so little had been done to enable the practical man to proceed with certainty in his attempts to improve the speed of ships. There were some points in which science had done all that can be desired. The immersion of a ship, her trim, her centre of buoyancy, her stability, can all be determined with accuracy beforehand, and the scientific naval constructor can proceed with certainty upon fixed scientific principles. It is otherwise with the speed and resistance of a ship. In nothing does calculation more completely fail than in the attempt to determine beforehand the speed of a ship constructed on given lines, or to show how a form may be so altered as to render it faster than before. To calculate the resistance opposed by the water to the passage of a ship through it, and to find that form which at a given velocity will pass through the water with least resistance, and of course with the smallest expenditure of power;

such was the problem hitherto the least resolved, and always one of the most important which these experiments were intended to investigate.

There were also two phases in which the problem presented itself, the scientific and the practical view of the subject: there were therefore two classes of experiments—those designed to advance our knowledge of the laws of hydrodynamics which govern the phænomena of resistance of fluids, and the other the experiments serving as a basis to the operations of the practical construction of ships, the *Experimenta Lucifera* and the *Experimenta Fructifera* of Lord Bacon.

Many experiments had formerly been made on this subject, but we had at that time so imperfect a system of hydrodynamics, that the conclusions drawn from them could not be relied on with confidence in the applications to be made on a large scale by the practical man. The Academy of Sciences had made a series of such experiments at large expense, defrayed by the French government. Colonel Beaufoy in our own country had made an important series of such experiments, at an expense of £30,000, but these were of comparatively little value for the same reason, viz. that the forms did not comprehend such forms as were actually required for the purposes of naval construction, and because the state of science was not such as to enable us, from the resistance of one form, to deduce with certainty that of another. One experiment of Colonel Beaufoy was of value, as it told us the resistance produced by the adhesion of water to the surface of a body independent of form, at various velocities. But the others were made on bodies not analogous to the forms of ships, and many of them on forms moved through the water far below the surface, and so suited to the construction of fishes or submarine navigation, but not for the purpose of sailing on the surface. For the purpose of giving practical value to the present series, experiments had been made on many different scales of magnitude, some in narrow channels, others in large canals, and finally on the open sea. Some were made on models of 3 feet in length, others of 10 feet; some on vessels 25 feet long, 75 feet long, and some on vessels 200 feet long and nearly 2000 tons capacity. Thus it was trusted that the scale of the experiments was such as to give confidence in the results. Next, as regards the forms of vessels made the subject of experiment, they were similar to those required for the practical purposes of construction. One class consisted of such forms as were required for steam navigation; plans of steam ships of the best construction, and others of worse forms, were accurately laid down on the same scale, in the same way and with the same accuracy of proportion as if they had been for actual construction, and along with these were some of new forms. A given form having been found to be a good one, was then varied by lengthening, first in one manner, then in another; now in the middle, now at the rear, now at the entrance, and so on, to discover the best mode of improving a given good form. In sailing vessels some of the celebrated Chapman's best forms were taken and treated in a similar manner, and along with them were compared the common forms of merchantmen and other ships. The class of fast-sailing yachts and cutters was treated in the same way, by taking some of the best known forms and determining by experiment the effects produced by lengthening and shortening them, making them fuller here, and finer there, and so ascertaining with accuracy the effect of each alteration of form on the great object of inquiry, namely, the determination in given circumstances of the method of giving such a form to a ship as shall enable her to pass through the water with the least resistance, the greatest velocity, and of course the smallest expenditure of force, power, and money. To these were added a number of theoretical and geometrical forms.

The methods of drawing these vessels through the water varied with the scale on which the experiments were made. Those on the smallest scale were drawn by a weight arranged in such a manner as to supply a uniform force through any given distance. Those on a larger scale combined the power of horses with the action of a weight, so as to apply their force, when freed from irregularities, to the same object. On a still larger scale the power of steam was employed, and on the largest scale the experiments were made on the sea by means of powerful towing vessels. In this way the experiments were made on a wide range of magnitude, both as regarded the vessels themselves and the sheet of water on which they were propelled—an element of resistance not always sufficiently taken into account.

The resistance was accurately measured by dynamometric apparatus of great accuracy, through which the moving force was communicated to the vessel; the velocity being determined in certain cases by a peculiar apparatus designed for this purpose, and in other cases by instruments for measuring and marking time with accuracy. The observations were registered by independent observers; carefully recorded by individuals employed for that purpose; then finally passed through a series of operations of reduction so as to fit them for immediate reference and use in calculation. After this process had been gone through by independent calculators, and not till then, were they made the subject of special examination with reference to every theory, and thus it was conceived that the greatest amount of authenticity had been secured.

The author then proceeded to give to the Meeting a number of specimens of the results which the experiments afforded, such as he knew were likely to interest those members of the Section who were acquainted with the principles of naval construction. He demonstrated a remarkable law by which it appears that each velocity has a corresponding form and dimension peculiar to that velocity; and he showed in a variety of diagrams the means of constructing such forms. To show how much influence *form* alone, without any other element or dimension, affects the question of resistance, he adduced the following as one of the most important experiments. Four vessels were taken, having all the same length, the same breadth, the same depth, the same area and form of midship section, and all loaded to the same weight, displacement and draft of water, the only difference being in the character of the waterlines; No. I., being of the new form indicated by these experiments as that of least resistance; No. III., the old form, very nearly the reverse of the first; No. II., intermediate between them; and No. IV. intermediate between No. I. and No. II. The following table shows the result of the comparative trial:—

Speed in Miles per hour.	Resistance in pounds.	Resistance in pounds.	Resistance in pounds.	Resistance in pounds.
	No. I.	No. II.	No. III.	o. IV.
3 miles.	10	12	12	11·3
4 ——	18	22	23	21·
5 ——	28	38	42	35·
6 ——	39	61	72	56·
7 ——	52	96	129	84·

These differences showed how much might be gained, everything else being equal, by the adoption simply of judicious forms in the construction of the water-lines of a ship. The vessel No. I. was constructed on the wave-line; the methods and rules for which he proceeded to explain by diagrams.

Mr. Scott Russell expressed to the Section the regret which he felt in the loss of Sir John Robison, who had been a zealous member of this Committee. One of his last acts had been to express his interest in their labours.

Report on the Physiological Action of Medicines. *By* J. Blake, *M.R.C.S.*

In regard to the following observations on the action of medicines I must beg to observe, that I have used the word medicine in its most general sense, and considered it as comprehending any body or force capable of exerting an influence on the animal economy. Under this point of view it is evident that the field of investigation is most extensive. The part of it to which I have more particularly directed my attention has been, the phænomena produced by the introduction of various substances directly into the blood. Although such an inquiry does not promise to lead to any direct practical results, it nevertheless offers to us the means of producing certain definite changes in the circulating fluid and in the tissues, in a much readier manner than we can hope to do by any other method; and there can be little doubt that a careful analysis of the facts thus obtained, will afford data which must sooner or later prove available for the advancement of medical science. In the last memoir which I published on this subject, I alluded to a fact which seemed indicated rather than proved by the experiments I had then made; this was, the apparently analogous action of isomorphous substances when introduced directly into the blood. But experiments which would bring into one class, as regards their physiological action, substances so dissimilar in their therapeutical properties as common salt and nitrate of silver, magnesia and iron, evidently required to be carefully repeated and extended, before they could admit of being received as data for founding so extraordinary a generalization: at the same time the importance of such a law, if discovered, affording, as it would do, the first step to a more scientific insight into the action of substances on the animal economy, appeared to me so evident, that I considered I could not better carry out the objects proposed to me by the Association, than by extending my researches in this direction, so as to verify or disprove the law in question.

I have also instituted a series of experiments to ascertain if in animals, with whose food foreign substances were mixed, these substances would combine with or be deposited in the tissues; and if so, whether they would be found in greater quantity in one tissue or organ than in another. For this purpose I have fed rabbits on food with which salts of strontian in one instance, and in another salts of lead, were mixed; conceiving that the strontian might possibly replace the lime in the bones, and that the lead would readily furnish me with facts, from the facility with which it can be detected, and from its uniting easily with the animal tissues, at least according to the generally-received opinion. The first series of experiments, or those with the salts of strontian, have led to only negative results, owing to the difficulty of separating strontian from lime. In my experiments with the salts of lead, I have arrived at conclusions which are opposed to the opinions generally entertained on the absorption and deposition of this substance: I therefore think it necessary to relate the experiments in detail.

I procured two full-grown healthy rabbits, and mixed six grains of acetate of lead with their food daily, so that each was taking three grains a-day;

either from the presence of the lead or some other cause, the animals did not appear at first to relish their food, but after a few days they ate as well as ever. After they had been taking this dose for ten days, the quantity of the acetate of lead was increased to six grains daily for each rabbit, and in five days more the quantity was increased to ten grains daily for each: they did not appear to suffer from this large dose, and it was again augmented to fifteen grains. After this dose had been taken for eighteen days one of the animals died, apparently from gradual inanition—there was no paralysis. The quantity of acetate of lead taken was 380 grains in the space of seven weeks. The only morbid appearances discovered after death, were redness of the lungs, and a thickened leathery state of the mucous membrane of the stomach, which was also lighter in colour than natural: the different viscera and the body were preserved for analysis. The other rabbit lived six weeks longer, the dose of the acetate of lead being gradually increased; for six days before its death, it was taking a drachm of the acetate daily; no symptoms of paralysis were observed, on the animal being allowed to run about, two days before it died. A post-mortem examination showed that the mucous membrane of the stomach had been the part principally acted on by the poison; it was so softened, that when the stomach was opened it remained adhering to the mass of food which the stomach contained, and without a careful investigation it was difficult to say if it was thickened mucus or the membrane itself that covered the food. The lining membrane of the small intestines and cæcum was also softened and reddened in patches; the colon and rectum natural. The mesenteric glands were enlarged and converted into a cheesy substance; tubercles were also found in the liver. The other viscera appeared healthy. At the time of its death this animal had taken upwards of four ounces of the acetate of lead, this substance having been mixed with its food during nearly three months. A careful analysis of the different viscera, with the exception of the stomach and intestinal canal, enabled me to detect the presence of lead only in the brain, in which organ it was found in both rabbits. Nor was I more successful in discovering it in the muscular tissue, or in the bones. 170 grains of the dried muscle from the first rabbit were heated with nitric and sulphuric acids, and then incinerated in an unglazed porcelain crucible: dilute hydrochloric acid was added, and the soluble portions removed by filtration; as by this means the greater portion of the salts, which interfere with the perfect combustion of the organic matter, was got rid of. What remained on the filter was moistened with nitric acid, and again burnt; this process being repeated until all the organic matter appeared quite destroyed: not the slightest trace of lead was discovered. The same process was pursued with the whole of the body of the other animal, with the exception of the viscera, which were analysed separately, and not the slightest trace of lead was discovered, although the animal had been taking it for three months, during which time it had swallowed more than four ounces. As in the last rabbit, the brain was the only part in which any trace of the poison could be detected; and here the quantity was so small as not to be appreciable by the balance, and must have been less than the hundredth of a grain, as that quantity could have been collected and weighed.

I think these experiments suffice to prove that, at least in rabbits, lead is not deposited in the muscular tissue. This result is certainly opposed to the commonly-received opinion on this point. I have only to observe, that the experiments have been conducted with the greatest care, and under favourable circumstances, as from the kindness of my friend Professor Graham, I had the advantage of conducting my analyses in his laboratory. A series of analogous researches have been conducted with the salts of mercury, but they are not yet completed. I trust on a future occasion to lay the results before this Section of the Association.

The experiments that have been performed on the action of substances when introduced directly into the blood, embrace salts of iron, nickel, manganese and cadmium, thus completing, with the experiments already published, the whole of the magnesian class *. I have also investigated the action of the acids of arsenic and phosphorus, between which well-marked isomorphous relations are known to exist.

As the action of each substance in the same isomorphous group closely resembles that of the others, I shall, for the first class, state generally the effects they give rise to, referring to the experiments which have already been published for more minute details. The most marked symptoms that follow the introduction into the blood of any of the salts of the magnesian family, are evidently due to an action they exert on the nervous system, an action so well-marked and so peculiar, as readily to distinguish this class of salts from any other substance derived either from the vegetable or mineral kingdoms with which I have yet experimented. Whilst most poisons that act on the nervous system, seem to exert their influence more particularly on the motor or sensitive properties of the nerves, these, on the contrary, afford an example of a specific action on the voluntary functions of the brain, or on the power of volition. When these salts are injected into the veins in proper quantities, the first effect that follows is generally vomiting; the animal then either falls or lies down, and will remain for many minutes in the same position, or in any position in which it may be placed, without once attempting to move, although it possesses the power of standing and walking about: the state in which it lies may be compared to that of catalepsy, were it not that, whilst in catalepsy the position of the limb remains unchanged from a want of power to move it, in the state induced by the injection of these salts, the limb is capable of being moved, but retains its position from the animal making no effort to change it. During the whole of the time the animal lies in this inert state, the sensibility remains perfect, and it appears quite free from pain; it turns its eyes in the direction of the person who may speak to it, and shows its sensibility when caressed, by slight movements of the tail, although lying in all other respects like an inert mass, with the exception of the respiratory movements, which continue with the greatest regularity. Sometimes the animal will remain in a most constrained position for many minutes, although so placed as to require a considerable degree of muscular exertion to retain it. I have, for instance, seen a dog remain for full five minutes with its fore legs bent under it, resting on the head and thorax and hind legs, although at the time it could walk about very well. Such are the symptoms that characterize the action of the whole of these substances on the nervous system: besides this, they exert a decided effect on the heart, destroying the irritability of that organ, when injected into the veins in larger doses. I have described fully in my former memoirs the action of this class of substances on the vascular system, and have only to add, that the salts of iron, nickel, manganese and cadmium, are perfectly analogous in this respect with those of magnesia, copper and zinc. The only difference between them is, as to the quantities required to produce the same train of symptoms; the quantity of sulphate of iron, dissolved in six drachms of water, which, when introduced into the jugular, will arrest the action of the heart, is from thirty to forty grains; of sulphate of nickel from ten to twenty grains; of sulphate of cadmium from five to eight grains; and of sulphate of manganese from ten to twelve grains.

* See Edinb. Med. and Surg. Journal, No. 148.

These quantities, however, must depend, to a certain extent, on the size of the animal, and on the rapidity with which the injection is introduced.

The marked and peculiar action which these substances exert on the nervous system, and the entire absence of any unpleasant symptoms when they are injected in moderate quantities, suggests the idea as to how far this property might be made available against some of the more violent convulsive diseases, such as tetanus and hydrophobia, against which the resources of our art are at present so powerless. Should any cases of these diseases come under my care, I certainly should try the effect of injecting some of these substances into the veins. I think the acetate of magnesia might be the most useful salt to employ; its permanent effects when introduced into the blood do not seem at all deleterious, as I have kept dogs ten or twelve days without any ill consequences, after introducing in one instance fifteen grains, and in another twenty grains into the veins. I should consider that from two scruples to a drachm dissolved in two ounces of water, could not possibly be injurious if introduced into the veins of a human being, and probably a much greater quantity might be borne without danger.

The only other class of substances with which I have experimented has been arsenic and phosphorus, which have been used under the form of arsenic, arsenious and phosphoric acids. It is a curious fact, that arsenic, one of the most violent of poisons, should, when introduced into the veins, even in much larger quantities than would be required to produce death if given by the stomach, give rise to no particular action on any organ which permits us to localize its effects, or to say that it kills by the changes it produces in any one tissue in preference to another. It certainly does not kill by its action on the heart, for when as much as twenty grains of arsenic acid are introduced into the veins, the action of the heart is but very slightly affected. Nor are the functions of the brain at all interfered with by so large a dose, at least not for some time. It would seem that it is not on any organ in particular that the poison acts, but that the whole of the tissues of the animal gradually lose their vitality, by changes which appear to require time for their production. After death, the mucous membrane of the lungs and the intestinal canal are the parts which present the most marked effects of the action of the poison, but the amount of lesion of these parts is often not sufficient to produce death. The similarity of action of the arsenic, arsenious and phosphoric acids is such, that I shall only give a detail of some experiments made with the former of these substances.

On injecting a solution containing three grains of arsenic acid, dissolved in six drachms of water, into the jugular vein of a dog, there was a diminution of pressure in the arterial system, as indicated by the hemadynamometer; after a short time the action of the heart became quicker, and the pressure in the arteries again increased; the functions of the nervous system did not appear deranged: on again injecting six grains the same phenomena presented themselves; the respiration, however, was now becoming very rapid, and this was the only marked symptom, when two other injections, one of fourteen and the other containing forty grains of the acid, had been introduced; at this time, however, the action of the heart had become much weaker, and the pressure in the arteries was only equal to a column of mercury of two inches; sensibility appeared unimpaired, and there were no convulsions. On again injecting sixteen grains of the acid, the action of the heart ceased after a few seconds. A post-mortem examination showed that both the mucous membrane of the lungs and intestinal canal had been much affected by the poison; they were both reddened, and were covered with a frothy secretion, which in the lungs must have greatly interfered with the arterialization of the blood. In another experiment a drachm of the acid was injected at once, without producing any marked symptoms, and the animal did not die until fifteen minutes after another drachm had been introduced into the vein. In most instances the blood has been found to coagulate less firmly than usual, but this has not always been the case. The symptoms produced by arsenious and phosphoric acids, when injected into the veins, are strictly analogous to those above described; the arsenious acid appears rather more poisonous than the arsenic, and the phosphoric may be considered as about equal to the arsenic. If concentrated solutions of either the arsenic or phosphoric acids are injected into the veins, the passage of the blood through the lungs appears impeded, and the irritability of the heart is destroyed.

These are the results at which I have arrived, and taken in connection with those I have already published, I think they fully justify us in concluding, that there exists a close relation between certain chemical properties of substances, and their action on organized beings. I am aware that such a doctrine has often been vaguely advanced, under a general point of view, but I think the experiments which I have brought forward are the first that tend to point out any scientific connection between the properties of bodies, and their action on organized beings: under a scientific point of view, too, this relation is the more interesting, as being connected with a property of matter which is manifested more particularly by the form it assumes; and it is well known, that in physiology, form is an important element in every phenomenon. As to the nature of the changes which these substances exert on the blood and tissues, and on which their physiological action would appear to depend, it would be absurd, in the present state of chemistry and physiology, even to hazard a conjecture. The mere fact of the nitrate of soda and the nitrate of silver, when injected into the veins, giving rise to analogous reactions on the animal economy, must suffice to show how far our present gross means of chemical analysis are incapable of seizing those more delicate changes of which living fluids and tissues are the seat; nor could any facts than those above brought forward, more strongly teach us the necessity of caution in admitting the hasty generalizations of those, who would attempt to explain the whole of the phenomena of living beings, by the glimmering light which chemistry in its present embryo state can afford.

Report of a Committee appointed to print and circulate a Report on Zoological Nomenclature.

The Committee, whose Report on the above subject appeared in the last volume of the Association, having recommended that extra copies of it should be circulated among British and foreign zoologists, and the sum of 10*l.* having been last year voted for that purpose, they now beg leave to report as follows:—They have paid 4*l.* 10*s.* to Messrs. Taylor for printing two editions of the Report in its incomplete state for the use of the members of the Committee; another sum of 4*l.* 10*s.* to Messrs. Taylor for printing 350 extra copies of the complete Report, and also for the cost of its insertion on an extra sheet in the Philosophical Magazine, and in the Annals of Natural History; and 1*l.* has been assigned towards the cost of transmitting the extra copies by post, making in all 10*l.* About 250 of the extra copies have already been distributed among scientific societies and individuals at home and abroad.

There seems every reason to believe that the principles of zoological language embodied in the Report alluded to are becoming very generally adopted and acted upon by foreign as well as British zoologists. The Committee have much gratification in announcing that their Report has met with a most favourable reception from the naturalists of Italy. At the scientific Congress held last year at Padua, the Prince Charles Lucien Bonaparte submitted to the meeting an Italian translation of our code of rules, which was generally approved of, and a committee of six zoologists and as many botanists was appointed to consider them in detail, and to report thereon to the meeting at Lucca in the present year. A French translation of our Report has appeared in the scientific journal called 'L'Institut,' in which paper much stress is laid on the importance of the measure. A very gratifying review of it has also appeared in the American Journal of Science. Let us hope that these efforts to produce uniformity in the scientific language of zoology will tend to facilitate intercourse between the naturalists of all countries, at once aiding the progress of their sciences and strengthening the bonds of their mutual amity.

H. E. Strickland
(on the part of the Committee).

Report of the Committee appointed by the British Association in 1842, *for registering the Shocks of Earthquakes, and making such Meteorological Observations as may appear to them desirable.*

The Committee take leave to report, that during the last twelve months the earthquakes in Perthshire have been more quiet than usual. From the end of June 1842 (down to which date its movements were last year reported by the Committee) only about thirty shocks have occurred at Comrie, to the first of July, 1843. The dates of these (the last year's shocks) will be found in a table annexed to this report; and in the same table has been inserted some meteorological information, furnished by Mr. Macfarlane of Comrie, who takes charge of the instruments belonging to the Association.

None of the Comrie shocks were so violent as to produce much, or indeed almost any, heave or undulation of the ground. They seem to have consisted of a sudden concussion only, accompanied by the usual trembling of the earth and rumbling subterranean noise.

In the table annexed to this year's report, and in compliance with the instructions given to the Committee, there is stated the quantity of rain and also the average height of the barometer for each month. If (as has been suggested) the rain which descends into the earth has some connection with the causes of earthquake shocks—perhaps the remarkable dryness of last autumn may, in part at least, account for the scarcity and slightness of the shocks at a season when they have been generally most frequent.

It is also not undeserving of attention, with reference to another speculation on this subject, that the barometer seems to have been particularly low at the time of the shocks. This at least was the case on the only two occasions on which the height of the barometer was marked at the instant of the shocks, viz. on the 24th of September 1842 and 23rd of March 1843. The barometer was then lower, not only than the average height for the month, but also than that of the day when the shock occurred. Thus, on the 23rd of March 1843 (as the table shows), the height of the barometer was at the moment of the shock, at 8 P.M., 29·12, and of another shock at 11 P.M., 29·10, whilst the average height for that day was 29·26, and for the month 29·72. The height of the barometer at the instant of the shock on the 24th of September 1842 will also be seen to have been lower than the average height for that month.

It is to be regretted that the height of the barometer was not registered on the occasion of all the shocks, so that there might have been on this point a wider field of induction. The Committee will endeavour to get this defect supplied in the observations of the ensuing year.

The first shock at Comrie on the 24th of September 1842, though by no means violent, was well marked by the instruments. The inverted pendulum placed in the steeple there (and which is ten feet long) had its head thrown to the north-west about one-eighth of an inch, indicating that its base had been suddenly moved thus much to the *south-east*. Another instrument, on the principle of the common pendulum, about four feet long, had its lower extremity thrown also one-eighth of an inch to the westward, indicating that its point of suspension had been suddenly pushed thus much *eastward*. Two other instruments, constructed so as to be affected by vertical concussions, indicated an *upward* heave of the ground to the extent of $\frac{1}{16}$th of an inch.

The instruments were affected on other two occasions, as stated in the register, but not in any very marked degree. Their indications entirely accord with the inference derived from the experience of shocks in previous years,—that the point from which they emanate is west-north-west from Comrie, and distant from it about a mile, or a little more.

The Committee will next notice the other places in Great Britain where during the last year they have learned that shocks have been felt. They will mention them in chronological order:—

August 19, 1842. At *Pitlochry*, between Dunkeld and Blair, about 8 P.M., three shocks were felt. It was remarked that the night was warm and sultry, with a drizzling rain, and that at midnight the thermometer stood at the unusual height of 72°.

August 22, 1842. A shock was felt in *North Wales*, and extended through the whole of Anglesea. The south-east portion of that island was most affected.

February 25, 1843. At *Oban* and *Lochgilphead*, in Argyleshire, as also in the intervening district, a shock was felt about 8 P.M. A person who felt this shock near Oban, described it to one of the Committee as producing a motion "such as one feels when standing near a heavy cart passing on a hard road made on a deep mossy bottom,—a sort of heaving and trembling at the same time." In a paragraph which appeared in the newspapers, it was stated that a person near Oban observed a flash of lightning about the time of the shock.

March 3, 1843. At *Lochgilphead* a shock was again felt about 8^h 40^m P.M. It was attended by the usual trembling and subterranean noise. It lasted from thirty to forty seconds.

March 10, 1843. Through the district to the north-east of *Manchester* an earthquake was felt about 8 A.M. Its most violent action was said to have been in the chain of hills separating Yorkshire and Lancashire.

March 17, 1843. About 1 A.M., the same district was again affected by a shock, but which on this occasion had a much wider range. It was felt simultaneously in *Lancashire*, *Cumberland*, *Dumfriesshire*, *Isle of Man*, *Belfast*, and even in the islands of *Jersey* and *Guernsey*. It does not appear to have been felt in the intervening district of the south and south-east of England.

This shock was accompanied by a noise which is described as resembling the hissing of steam or the rushing of wind. The ground also trembled, and in some places heaved. Even at Belfast and its neighbourhood, where the effects produced have been reported on by Mr. Bryce, a member of the Committee, the particular phænomenon now adverted to was perceived. Mr. Bryce says, "that the motion was that of a ship in a heavy swell, and the feeling was given that the room and bed were rolling over." By another it is described as like "that rolling motion of a ship which induces nausea;" and this individual actually experienced that sensation in a slight degree. Another compared the concussion to "what a sudden and strong gust of wind would produce, or a loaded cart passing along the street."

Mr. Ronchetti, who resides at Salford, near Manchester, found his barometer at 8 P.M. on the preceding evening (viz. about five hours before the shock) standing at 29·90. He sat up reading till 2 A.M., *i. e.* an hour after the shock, but without perceiving it. His barometer was then standing at 29·70, so that it had fallen nearly two-tenths during the five hours preceding the shock. A correspondent at Ulswater states that he observed his barometer also falling during the previous afternoon. Mr. Atkinson's Meteorological Register, near Carlisle, shows that at 9 P.M. on the 16th of March the barometer was 29·794; at 9 A.M. on the 17th it was 29·736; and at 9 P.M. on the same day 29·750, being lowest therefore near the time of the shock. There thus seems to be little doubt that the shock occurred with, as usual, a falling barometer.

In a notice of the same shock, dated at Fleetwood-on-Wyre, it is mentioned, that during the whole of the previous afternoon the sky presented a gloomy and lowering appearance. The air was unusually close, and a dense haze hung over the sea.

At and near Manchester the shock was said to have been felt coming from a few points to the south of east. In the Isle of Man the shock was followed by a sensible vibration from *east* to west. At Keswick, Gosforth and other places in Cumberland, the shock was felt to come from the *south.* In the counties of Dumfries and Selkirk it was perceived to come from the *south-west.* These data appear to indicate pretty clearly that the shock had radiated from some point between Yorkshire and Lancashire, and accordingly it was stated to have been felt in Newcastle and its neighbourhood, though not so severely as on the west side of the island.

This shock produced, as might have been expected, sensible effects below the earth's surface. It was distinctly felt in the coal-mines between Bury and Bolton, and alarmed the people so much as to make them run to the bottom of the shaft and call to be drawn up. In the same neighbourhood some workmen were engaged in boring, and had gone down about thirty yards, of which the lowest, ten yards, consisted of rock, above which there was a thick bed of sand, gravel and marl. On account of the looseness of these materials, seven or eight yards of the hole was piped with a strong tin casement, out of which, when the men left the work in the evening preceding the earthquake, a clear stream of water was issuing. When they returned to their work next morning the stream was not issuing; and, moreover, in attempting to put their boring-irons down the hole, it was found that they would not pass as usual. The tin casement was then drawn up to be examined, when it was found to have been completely flattened and slightly bent, so that the light could not be seen through it. These effects were at the time attributed to the action of the earthquake on the materials of the strata through which the bore had been made.

It is scarcely necessary to observe, that the different shocks above referred to as having occurred in Perthshire, Argyleshire, Wales, and the district of England last mentioned, all *originated* in these different localities, or rather in depths immediately below these respective portions of the earth's surface. But whilst, as the experience of former years shows, these districts are very liable to be affected by earthquakes, they do not seem to have any common bond of connection. That is to say, a shock which rises up in any one of these districts is not felt in the others; from which it is reasonable to conclude, that the cause of the shocks (whatever that may be) was in these cases at least not seated at any great depth below the surface.

It is supposed by many, that when shocks occur in this country they are produced by subterranean changes taking place in the volcanic regions of the earth. If this opinion were well-founded, shocks should occur in this country and in those regions almost always at the same time. But seldom is there such coincidence perceivable; though of course it may sometimes accidentally happen, that shocks should occur in this and in some other part of the earth about the same time. As an example of these accidental coincidences, it may be observed, that on the 3rd of March 1843, when, as already mentioned, a shock was felt at Lochgilphead, there was a slight earthquake at Guadaloupe. But, on the other hand, the more serious earthquake of the 8th of February 1843, which convulsed the whole West India Islands, and destroyed several towns in Saint Domingo, was not marked in this country by any corresponding phænomenon, as would undoubtedly have been the case if the shocks in this country are produced by the excitement of volcanic action in other regions.

The reference now made to the West India earthquake of 8th of February last, affords an opportunity of submitting to the Association a suggestion for extending the field of the Committee's inquiries. Though, by the terms of their appointment, they are not expressly limited in their inquiries to Great Britain, they certainly did not understand that they were to have a wider range. But if it be an object worthy the attention of the Association to collect from all quarters information calculated to throw light on the causes of earthquakes, there seems no reason why they should not make it part of the business of this Committee to receive and digest notices of foreign earthquakes. The one above referred to, which occurred in the beginning of the present year in the West Indies, and the effects of which were sensibly felt even in the Brazils, as well as in Mexico and in Ohio, affords very instructive details, which the Committee would have gladly availed themselves of but for the doubt above suggested.

The Committee have had their attention drawn to this proposed enlargement of their field of inquiry, by two letters received by one of their number from two gentlemen, one of whom is now in India, and the other of whom is about to settle in Peru.

The former gentleman, Lieutenant Baird Smith of the Engineers, and superintendent of the Doab Canal in Upper India, thus writes from the Himalayas on the 9th of September last:—"Having occupied myself for some time past in collecting information relative to the occurrence of earthquakes throughout British India, I venture to place myself in communication with you, and through you to offer to the Committee my most cordial co-operation, so long as I may remain in this country. My attention was first specially attracted to the subject of earthquake-shocks by the occurrence of that of the 19th of February last, to which many circumstances combined to give to the English in India a peculiarly exciting interest. Its most destructive influence was experienced in the valley of Jellalabad, the chief town of which of the same name was at the moment occupied by the small but gallant brigade under Sir Robert Sale. The details of this earthquake, which were felt from Jellalabad to Shalkur in Thibet on the north, and to Saharampore on the south, I collected as they became known, and have arranged and published in the local journals. The effect more than equalled my anticipation, for a large amount of additional information was furnished to me, and I have received assurances of active co-operation. Numerous corrections are necessary in my paper on the Jellalabad earthquake, and these it is my intention to make when I prepare the 'Register of Indian Earthquakes for the year 1842,' materials for which are rapidly accumulating.

"It would be a source of pleasure and satisfaction to me to work in connection with the Committee of the British Association, and to receive from it from time to time such information and advice as would facilitate my labours here. It has often struck me that the Association, in neglecting any systematic effort to link colonial science with that of the mother country, is losing noble fields of exertion, and has failed in what ought to have been one of its essential objects. Looking to India only,—to how many points of the deepest interest might not materials be contributed from it? Yet the Association seeks not to stimulate and guide the necessary inquiries. There are many qualified men in the Indian army and civil service who require only a little encouragement to ensure their co-operation in any scientific efforts; and to those interested in India, the apathy and indifference regarding it that prevail at home are painful topics of remark. When the Association was first established an Indian sub-committee was appointed; but no correspondence appears to have been maintained with it, and no steps taken to fill vacancies in it. It is now quite extinct, but might easily be called again into being and activity were it considered advisable that it should be."

The letter from which these extracts have been quoted contains some interesting information in regard to those portions of India most affected by earthquakes, which it would be out of place to embody in the present report, the more especially as it was published in the last January Number of the Edinburgh Philosophical Journal. But the above extracts are given, in order that the Association may consider the two points submitted to them by Lieutenant Smith, viz.—(1.) Whether they will authorise this Committee to receive from him, to be embodied if they see fit in their annual report, such information as may be sent to them by him or others in regard to Indian earthquakes. (2.) Whether the Association would reappoint the Indian sub-committee to which he refers, the precise objects or duties of which are however not known to the present reporter.

The other letter above referred to is from Mr. Mathie Hamilton, M.D., the author of various articles on South American earthquakes, and on the Lama, Alpaco, and other animals in South America, which were published in the Edinburgh Philosophical Journal.

Mr. Hamilton, who has resided for many years in Peru, and had turned his attention to more than one branch of its natural history, intimates in his letter the intention of returning to Peru, and of permanently residing there. The object of Mr. Hamilton's communication is hinted at in the following extract from his letter, which is dated the 6th of August 1843:—"My object in this communication is, that if either you or any of your friends would suggest any inquiries connected with the causes and phænomena of earthquakes, I will most cheerfully, in so far as may be in my power, attend to such suggestions. I am a subscriber to the book-fund and a life member of the British Association, and if in any mode I can assist the objects of the Association I will do so. On the 6th of June last I was at Comrie, and saw some of the instruments; I think that the 39-inch pendulum (not the noddy) and the instrument which is attached to the wall in Mr. Macfarlane's attic for measuring the vertical movements, are those which will be found most convenient in Peru. I wish to go to the meeting in Cork, but I fear that the necessary arrangements for my projected voyage may prevent me."

The member of your Committee to whom Mr. Hamilton addressed this communication had some conversation with him, and is impressed with the conviction, that if the Association thinks it desirable to receive information respecting earthquakes in Peru, a better opportunity could scarcely present itself than that which now occurs. Considering, as he does, that it is desirable to receive information on this important and yet ill-understood subject, not merely from Peru and India, but from every other country where the phænomena are well developed, he would suggest that both Lieutenant Smith's and Mr. Hamilton's offers should be accepted; and, moreover, that two or more instruments, at the expense of the Association, should be put under Mr. Hamilton's charge, if he will undertake to register their indications and report them half-yearly to the Committee.

With regard to British earthquakes, and particularly those which occur so frequently, indeed almost periodically in Perthshire, the Committee entertain a hope, that if the Association will authorize them to continue their superintendence, they may eventually gather much information which will prove valuable in any inquiry into the origin of them. In Perthshire, where instruments have, at the expense of the Association, been erected, it is quite necessary that means should, as before, be supplied to watch and register their indications. There are other two localities in that part of Scotland where instruments should be placed, viz. Ardvoirlich (about ten miles west of Comrie) and Tyndrum (about forty miles north-west of Comrie). Most of the instruments now in Perthshire are either in the town of Comrie or to the east of it, and it is considered desirable that there should be the means of marking the directions of the shocks on opposite sides of the supposed focus of action. Mr. Stewart, the proprietor of Ardvoirlich, has undertaken the charge of the instrument proposed to be sent there; and Lord Breadalbane has authorized the manager of his mines at Tyndrum also to take charge of one, and to register its indications. Instruments for these places have been ordered.

The Committee take leave to repeat the wish which they expressed in last year's report,—to have instruments placed at Comrie for the purpose of marking more frequently meteorological changes in that district. There is already at Comrie a barometer and a thermometer belonging to the Association, the state of which is registered only in the morning and evening. But it would be desirable that this town should be one of the stations of the Association for *hourly* observations of the barometer, for reasons which are well known to all who have studied the subject. Moreover, if there be any instrument sufficiently perfect to indicate the varying electrical condition of the earth and atmosphere, there certainly should be one sent to Comrie.

But perhaps it would be proper to leave this part of the subject in the hands of the Meteorological Committee of the Association, a duty which it is understood that they are willing to undertake, and the importance of which is well appreciated by the convener of that Committee.

(The Committee annexed to their report an account of the expense incurred by them during the last year, which amounted only to £10.)

They respectfully suggest that the Committee should be reappointed, with such additional or such other persons to be members of it as the Association may see fit, and with the sum of £100 at their disposal, as hitherto. If the Committee might venture to suggest any new names to the Association, it would be those of Mr. Darwin, so well known for his paper on South American volcanoes, and also Mr. Mathie Hamilton, if the Association should agree to the proposal which has been made to them.

WM. BUCKLAND.
DAVID MILNE.

REGISTER FOR

EXPLA-

A The hours of the day before noon indicated by A, the hours after noon indi-
the after-

B Marking the least perceptible shock as 1, and a shock equal to that on Oct. 23, 1839, as 10,
loud as the shock re-

C If the concussion be single, to be marked C; if double, CC; but if the second be smaller
would indicate two shocks, the

D Entered C, H, or T, according as it is a Crash, Heave, or Tremor, or two, or all;
indicate a shock beginning with a slight concussion, then a considerable heave, and
the three qualities

E The first column here is merely for entering the direction the shock *appeared* to the
the Dip to be entered of course only where the

F In like manner, in these columns the height of Barometer and Thermometer is en-
wind indicated by 1 for the gentlest current,

G Where there is no rain-gauge the quantity of rain to be marked in general by the letters

Year 1842-3.	A Time of the day.			B Violence of the		Duration in Seconds.		C	D	E Direction.				F Instant of Shock.				
											Marked by the Seismometer.					Wind.		
Day of the Month.	Hour.	Minute.	A or P.	Shake.	Sound.	Shake.	Sound.	Concussion, single or double.	Crash, Heave, Tremor.	As felt.	Point of Compass.	Extent of Vibration.	Dip in parts of an inch.	Barometer.	Thermometer.	Direction.	Strength.	Sky dark or clear.
July 1.	2	30	P	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
— 1.	4	30	P	1	"	"												
— ?	9	...	A	1														
— 10.	3	30	P	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Aug. ?	?	...	?	?	...	...	...	...	...	...	...	...	...	...	...	...	...	...
— ?	?	...	?	?														
— ?	?	...	?	?														
— 27.	11	45	P	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Sept. 2.	3	...	A	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
— 24.	5	53	A	3	4	3	3	C C	C t T	...	W	$\frac{1}{8}$	$\frac{1}{16}$	...	...	E	...	Cl.
— 24.	6	59	P	2	3	3	3	C	c T t	N W	W	$\frac{1}{8}$	...	29·528	55½	N	2	D
— 25.	?	...	A	1														
— 25.	?	...	A	1														
Oct.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Nov. 18.	12	...	P	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
— 29.	12	11	P	1	1	1	2	...	t	...	...	...	...	...	...	...	...	...
Dec. 4.	2	...	A	0	1	0	1	...	o	...	...	...	...	...	...	...	...	...
— 17.	8	...	A	1	1	1	1	...	t	...	...	...	...	...	...	...	...	...
— 17.	?	...	A	1	1	1	1	...	t									
— 17.	?	...	A	1	1	1	1	...	t									
Jan.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Feb.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mar. 23.	8	30	P	2	2	2	3	...	c t	...	...	...	...	29·12	...	E	1	D
— 23.	11	...	P	1	1	...	...	...	t	...	...	...	...	29·1	...	...	...	...
April.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
May 14.	1	...	A	1	1	...	...	...	t	...	...	...	...	...	...	SE	2	D
— 14.	2	...	A	1	1	...	...	...	t	...	...	...	...	...	...	...	...	...
— 28.	12	20	P	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...
June 4.	12	15	P	2	2	2	3	C	T	E	E&W	$\frac{1}{8}$	$\frac{1}{16}$	...	...	...	...	Cl.
— 4.	3	...	P															
— 10.	2	30	A	2	2	2	2	...	...	...	...	...	...	...	...	...	...	...
— 10.	3	...	A	1	1	1	1											
— 15.	...	...	...	1	1	1	1	...	...	...	...	...	...	...	...	...	...	...
— 17.	4	...	A	2	2	2	2	C	T	...	...	...	...	...	...	...	...	...

EARTHQUAKE SHOCKS.

NATIONS.

cated by P; thus, 4 o'clock in the morning is marked in the Table 4 A; 4 o'clock in noon, 4 P.
and intermediate degrees of intensity by intermediate numbers; thus, one half as violent or ferred to, to be entered 5.
than first (which is almost always the case) the latter to be marked with a small c; thus C c second weaker than the first.
using the small letters here too to mark the relative force of each; thus c H t would ending in a slight tremor; and C H T, one such as that of Oct. 23, 1839, where all were intense.
observer to proceed from, most needed in slight shocks that do not affect the instruments; instrument enables the observer to ascertain it.
tered only by those observers who have such instruments at hand. The strength of the and 10 for a hurricane; and a calm, 0.
M, much, and L, little.

F					G			
Five minutes after Shock.					Rain for eight days previous.	Rain during each month, in inches.	Average of Barometer for each month.	Other particulars not included in preceding list, that might be considered as either directly or indirectly connected with the shocks.
		Wind.						
Barometer.	Thermometer.	Direction.	Strength.	Sky dark or clear.				
...	...	...	...	...	...	July 2·59	July 29·78	July 1. Fine day and night. Wind westerly.
...	...	...	...	...	...	....	....	July 10. Wind moderate and westerly. Day showery.
...	...	...	...	...	...	Aug. 1·56	Aug. 29·93	
...	...	...	...	...	...	....	....	Aug. 27. Beautiful sunny morning. Light easterly wind.
...	...	...	...	...	...	Sept. 2·86	Sept. 29·75	
...	...	...	...	Cl.	L	....	....	Sept. 24. Barometer and thermometer were stationary for three quarters of an hour after shock. At Comrie shake most violent in middle; at Cluan most violent in commencement. Whilst one of Seismometers had head thrown to north-west one-eighth of an inch, another of a different kind thrown west to same extent.
29·528	55½	N	2	D	L			
...	...	...	...	...	...	Oct. 0·88	Oct. 29·87	
...	...	...	...	...	...	Nov. 2·80	Nov. 29·62	
...	...	...	...	...	...	....	....	Nov. 29. Fine day, but cloudy and showery.
...	...	...	...	...	...	Dec. 6·10	Dec. 29·75	Dec. 4. Morning and evening cloudy. A red sun-set.
...	...	...	...	...	...	....	....	Dec. 17. Cloudy and showery day; towards evening rain and wind. These three shocks served only at Tomperran, not at Comrie.
...	...	...	...	...	...	Jan. 2·91	Jan. 29·43	
...	...	...	...	...	...	Feb. 1·04	Feb. 29·69	
29·12	...	E	0	D	M	Mar. 3·22	Mar. 29·72	March 23. Day very foggy, dark and rainy; very heavy showers at 4 p.m. Barometer at 9 a.m. 29·17; at 9 p.m. 29·35.
...	...	...	...	...	M			
...	...	...	...	...	...	April 5·17	Apr. 29·59	
...	...	SE	2	D	L	May 3·56	May 29·60	May 14. Showers and cloudy; a blink at noon; at 1 p.m. and after, chill and cloudy.
...	...	...	...	...	L			
...	...	...	...	...	M	....	....	May 28. Cloudy; cold wind; slight showers after 5 p.m., very cold.
...	...	...	...	Cl.	M	June 2·22	June 29·90	June 4. The first shock felt with equal severity at Comrie, Clatheck (two miles east) and Invergeldy (six miles north of Comrie). The second shock observed only at Clatheck.
...	...	...	...	...	M	....	....	June 10. Cloudy, with occasional sunshine; rather cold, and windy evening.
...	...	...	...	...	L	....	....	June 15. Clear sunshine and very warm. Two additional shocks thought to have occurred today.
...	...	...	...	...	L	....	....	June 17. Clear sunshine and very warm.

Report of the Committee for conducting Experiments with Captive Balloons.

The requisite apparatus is nearly complete. The balloon, 18 feet in diameter and 25 feet high, has been received at Woolwich by Colonel Sabine. Mr. Wheatstone's electric thermometer has been tried, and found to act in the most perfect manner at distances of some miles, and we have ordered the addition of another part for giving the hygrometric indications. A series of experiments has been made on the strength and weight of cordage of various kinds of fibre; the proper quality has been decided on, and I am happy to state that Mr. Enderby, who has taken great interest in these inquiries, will present the necessary quantity of it to the Association.

Of the original grant of 250*l.*, 81*l.* 8*s.* have been expended.

The Directors of the Woolwich Gas-works have shown every wish to accommodate us, and assisted us in our preliminary experiments so as to make the inflation of the balloon perfectly manageable.

To complete the advantages of our position at Woolwich, I would suggest it as extremely desirable that a request should be made by the Association to the Master-General of the Ordnance, entreating his assistance.

T. R. Robinson,
Chairman of the Committee.

August 17, 1843.

Appendix to the Report, by Professor Wheatstone.

The Telegraph Thermometer which is intended to be carried up by the balloon, weighs, with its case, about four pounds. It is thus constructed:—The movement of a small clock causes a vertical rack to ascend and descend regularly in six minutes, three minutes being occupied in the ascent and three in the descent. The rack carries a fine platina wire, which moves within the tube of a thermometer; the extent of motion of this wire corresponds with 28° of the thermometric scale, but it is capable of adjustment so that it may pass over any 28° of the range. Two very fine copper wires, covered with silk, and of sufficient length to reach from the ground to the balloon when at its greatest elevation, are connected with the instrument in the following manner:—The extremity of one wire is connected with the mercury in the bulb of the thermometer, and that of the other wire with the frame of the clock, which is in metallic continuity with the platina wire. On the ground the lower extremities are united together; in the wire, whose opposite end is connected with the mercury in the thermometer, a sensible galvanometer is interposed, and in the course of the other wire a single, very small voltaic element is introduced. The galvanometer having been properly adjusted to its zero point, it will remain so during the time that the platina wire is not in contact with the mercury in the tube, but the needle will deviate as soon as the contact takes place, and will remain deflected until contact is again broken during the ascent of the rack. During each half-second of time, corresponding with the beats of the clock, the wire moves through the 360th part of its range, and a different point of the range consequently corresponds with a different beat or half-second of each alternate three minutes. If, therefore, an observer below be furnished with a chronometer timed to coincide with the clock in the balloon above, and note at what instant the needle of the galvanometer is deflected, he may infer from that observation the temperature indicated by the thermometer in the balloon; for according to the different expansion of the mercury in the thermometer the contact is broken at a different half-second. Should the rates of the two time-pieces not exactly correspond at the conclusion of a series of observations, the results will not be vitiated, as a correction may be easily made.

It is intended to add to this apparatus a wet-bulb thermometer; this will involve only the addition of another platina wire to the rack, and of another insulated wire, reaching from the balloon to the earth, with its interposed galvanometer.

For other meteorological instruments, the indications of which are to be transmitted to a distance, I occasionally employ the agency of electro-magnetism to ring a bell, to mark with a type or pencil, &c.; but for the purpose in question such methods cannot be so conveniently employed as the deflection of the needle of a galvanometer, on account of the necessity of having the long conducting wire extremely fine in order to avoid adding too much to the weight of the balloon. If the electro-motive force of the rheomotor were increased, which it would be necessary to do were stronger currents required, sparks would occur at the surface of contact of the mercury, which would produce injurious effects.

Report of the Committee for the Translation and Publication of Foreign Scientific Memoirs.

Since the last meeting of the British Association the Committee have obtained and published in the 10th and 11th Numbers of Taylor's "Scientific Memoirs," translations of the four following works, viz.—

1. Gauss's Dioptric Researches.
2. Dr. Lamont's Account of the Magnetical Instruments in use at the Observatory in Munich.
3. Gauss on the Magnetic Inclination at Göttingen.
4. Dr. Lamont's Results of Three Years' Magnetical Observations at Munich.

The first of these translations was presented to the Committee by Professor Miller of Cambridge, and the three others by Lieut.-Colonel Sabine. A plate accompanying the translation of one of Dr. Lamont's memoirs has been engraved at the expense of the Association, but as the account of its cost, though requested some time since, has not yet been sent in, there has been no expenditure under the direction of the Committee in the past year.

(Signed in the name of the Committee) Edward Sabine.

On the Habits of the Marine Testacea. By C. W. Peach.

The author commenced with stating that *Purpura lapillus* deposits its nidi all the year round, but most actively in the first four months of the year; the young escape from the nidi in about four months.

Buccinum reticulatum deposits its nidi on weeds, stones, and the wicker-work of the store pots of the crab-catchers; they are strung together and overlie each other like the brass scales on the straps used for holding on the caps of soldiers; they are of the shape of the spade on playing cards.

The author is of opinion that the *Patella lævis* and *Patella pellucida* are the same shell, the one being the young state of the other. He then went on to describe the *Fissurella nubecula*, and to show that this shell has a serrated instead of a plain margin, and that the apex is surrounded by three teeth. In consequence of it having been asserted at the Meeting of the British Association at Plymouth that the *Saxicava rugosa* was not an inhabitant of deep water, the author stated that he had got specimens alive in limestone five leagues from the land and in thirty fathoms water. *Pholas lamellata* was found also under similar circumstances in red sandstone. He next proceeded to describe the *Pholas dactylus* which he had found in clay-slate in Cornwall, and to describe particularly the form and actions of the animal, which he had kept alive in his house more than a month (there were fifteen or sixteen shells of all sizes), and although he marked the slab in which they were, he could not perceive that *they turned round for the purpose of boring*. In the same slab he also found *Pholas parva*.

Report on the Mollusca and Radiata of the Ægean Sea, and on their distribution, considered as bearing on Geology. By EDWARD FORBES, *F.L.S., M.W.S., Professor of Botany in King's College, London.*

THE British Association having done me the honour of requesting a report on the Mollusca and Radiata inhabiting the Ægean and Red Seas, considered more especially in their bearings on questions of distribution and of geology, I have now the pleasure of laying before this meeting such portion of it as relates to the eastern Mediterranean. The data upon which it is founded have been entirely derived from personal research during a voyage of eighteen months in the Ægean, when but few days passed by without being devoted to natural history observations. The calculations in the following pages have been based upon more than 100 fully recorded dredging operations in various depths, from 1 to 130 fathoms, and in many localities from the shores of the Morea to those of Asia Minor, besides numerous coast observations whenever opportunity offered. The circumstances under which these researches were made were peculiarly propitious. The merit of the results obtained is mainly due to Captain Graves in command of the Mediterranean Survey, at whose invitation the reporter joined H.M.S. Beacon as Naturalist, in April 1841, from which time, until his departure for England in October 1842, every possible assistance and means of observation were put at his disposal by that distinguished officer, and every cooperation afforded by the officers of the Survey. Without such aid it would have been quite impossible to have obtained the results now laid before the Association, which, from their having been made in connection with the Hydrographical Survey, may assume a value to which no private observations could lay claim*.

The Ægean Sea, although most interesting to the naturalist as the scene of the labours of Aristotle, has been but little investigated since his time. The partially-published observations of Sibthorpe, and the great French work on the Morea, include the chief contributions to its natural history. In the last-named work are contained catalogues of the Fishes and Mollusca, with notices of one or two Annelides. In all the marine tribes my lists greatly exceed the French catalogues, more than doubling the number of Fishes, and exceeding that of Mollusca by above 160 species, not to mention Radiata, Amorphozoa and Articulata. In the present report I propose to give an account of the distribution of the several tribes of Mollusca and Radiata in the eastern Mediterranean, exhibiting their range in depth, and the circumstances under which they are found; to inquire into the laws which appear

* A great portion of the observations among the Cyclades were made jointly with Lieut. Spratt, Assistant Surveyor of the Beacon, and of those relating to the coasts of Asia Minor with Mr. Hoskyn, late Master of the Beacon, and now Assistant Surveyor of H.M.S. Lucifer. Many independent observations of great value to the author were made by Lieut. Freeland, Lieut. Mansell, Mr. Chapman, and other officers of the Beacon, and he is desirous of recording his thanks to all the gentlemen named for their kindness in placing their collections at his disposal. He is happy to say that the Ægean researches have not ceased with his departure, Capt. Graves and his officers being actively engaged in natural history investigations in addition to their many scientific duties during the survey now in progress of the Island of Candia.

to regulate their distribution, and to show the bearings of the investigation on the science of geology.

I shall commence with an enumeration of the species of Mollusca and Radiata, prefacing the tabular view of each tribe with a few general remarks.

Mollusca.

Cephalopoda.

Octopus vulgaris and *macropodius*, *Sepia officinalis* and *Sepiola rondeletii*, were the cuttle-fishes which I met with in the eastern Mediterranean. They are all inhabitants of the shallows, and are found in or near the littoral zone, where they are much sought after by the Greeks as articles of food. They are speared at night by torchlight when on their foraging excursions. The sandy shores of the island are thickly covered with the shell of the Sepia, sometimes forming beds of considerable thickness. In no instance did the shell occur when dredging, so that we may suppose that species to be confined to the littoral zone. The *Sepiola rondeletii* was taken on the coast of Asia Minor, as deep as 29 fathoms in a bottom of weed. *Octopus macropodius* only occurred once, and then among the rocks near watermark, in the Island of Cerigo, at the entrance of the Ægean. The *Argonauta* was much sought after, but never found. It is, however, a recorded inhabitant of the shores of Greece.

Pteropoda.

Eight species of Pteropoda, members of the genera *Hyalæa*, *Cleodora* and *Criseis*, inhabit the Ægean, and appear to be equally diffused in all parts of the eastern Mediterranean. The white mud which forms the sea bottom between 100 and 200 fathoms abounds with their remains, many hundreds coming up in a single dredge, chiefly *Criseis* and *Cleodora*. In the muddy deposits of upper regions they are scarce, in those of shallow water altogether absent. Though immense numbers of their dead shells were taken, comparatively few of these testacea occurred in a living state. Of the eight species four were taken alive, three of which were *Criseis*, and the fourth *Hyalæa tridentata*. The last was only observed once in the Bay of Cervi, at the entrance of the Ægean, in August 1841: the *Criseis* were abundant in the spring of the same year. They usually abound about three hours after noon and towards nightfall, sparkling in the water like needles of glass. Throughout the summer and autumn they were very seldom met with. It would appear that great flocks of Pteropoda live in the deeper parts of the sea, ascending to the surface only occasionally, and at definite seasons. That their range in depth is limited, is evident from the fact that their remains abound only between 100 and 200 fathoms, diminishing above and below that region.

Nucleobranchiata.

Seven species of undoubted Nucleobranchiata, with three probable members of that order, inhabit the Ægean, representatives of genera, four of which are shell-bearing and two naked. The observations regarding habitat and time of appearance apply equally to the members of this order and those of the last, with the exception of the *Firolæ*, which may be seen during most months of the year. Of the testaceous nucleobrancs, the *Atlanta peronii* and two species of *Ladas* appear to be universally diffused in the Ægean. *Carinaria* is very rare, having only occurred twice, and then dead. A little shell of Bellerophon-like appearance is abundant in the mud of great depths, and from its resemblance to the young state of *Carinaria* I have placed it here. Two species of that very anomalous genus *Sagitta* were met with occasionally, and were frequently examined in the hope of throwing new light on their true position in the animal kingdom. All the naked nucleobrancs of the Ægean are extremely active animals, rapid in their movements, and ferocious in their habits.

Pteropoda and Nucleobranchiata.

	No. of Ægean Species.	No. of Mediterranean Species.	Observations.
PTEROPODA.			
Hyalæa, Lam.	3	4	
1. tridentata, *Forsk.*	......	......	Living, Cervi. Dead, Lycia, VIII.
2. gibbosa, *Rang*	......	......	Dead in Region VIII., common.
3. vaginellina, *Cantr.*	......	......	Dead in Region VIII., frequent.
Cleodora, Per. and Less.	2	2	
1. cuspidata, *Bosc.*	......	......	Dead, v. r. Region VIII.
2. pyramidata, *Péron.*	......	......	Dead, common. Region VIII. [abundant.
Criseis, Rang	3	3	
1. spinifera, *Rang*	......	......	Living, common. Dead, R. VIII.,
2. striata, *Rang*	......	......	Living, rare. Dead, R. VIII. frequent.
3. clava, *Rang*	......	......	Living, common. Dead, R. VIII., abundant.
NUCLEOBRANCHIATA.			
Atlanta, Less.	1	1	
1. peronii, *Less.*	......	......	Living, rare. Dead, R. VIII. frequent.
Ladas, Cantr.	1	2	
1. planorboides, *Forb.*	......	......	Dead, R. VIII., not rare.
? *Bellerophina*, D'Orb.	1	1	
1. minuta, *Forb.*	......	......	Dead, R. VIII., common.
Carinaria, Lam.	1	1	
1. mediterranea, *Per.*	......	......	Dead, R. VIII., v. r. Nid.
Peracle, Forb.	1	1	
1. physoides, *Forb.*	......	......	Dead, R. VIII., not common.
Firola, Per. and Less.	3	5	
1. frederica, *Less.*	......	......	Frequent.
2. hyalina, *Forsk.*	......	......	Frequent.
3. sp.	......	......	Rare.
Sagitta, Q. and Gaim.	2	2 or 3	
1. mediterranea, *Forb.*	......	......	Not frequent.
2. Sp. alt.?	......	......	Not frequent.

Gasteropoda Nudibranchia.

The absence of tides is extremely unfavourable to the presence of animals of this beautiful tribe, nevertheless numerous species are recorded as inhabitants of the Mediterranean. In the eastern division of that sea, however, they are scarce, and but seldom met with. The only species observed in any quantity was a large red Doris (*D. argo*) which frequents the rocks of the coast of Lycia, close to the water-mark, laying its bright red spawn in sponge-like masses on their surface. Another member of this genus was found at a depth as great as fifty fathoms. Of the allied genus *Goniodoris* several very beautiful species were obtained. The characteristic Nudibranc of the Mediterranean, a giant among its tribe, *Tethys leporina*, was only met with once, swimming foot up on the surface of the sea in the Gulf of Smyrna, in an exhausted state, its sides being infested by that extraordinary parasite the *Vertumnus tethydicola*. Out of fifteen species of *Nudibranchia* taken in the Ægean, three are certainly, and four probably identical with species inhabiting the coast of Great Britain, living at similar depths and under similar circumstances.

Nudibranchia.

Species.	Spec. in Med.	Species in Ægean.	Range in Depth.	Ground.	Locality.	Geographical Range.
Doris, Lin.	?	5	fathoms.			
coccinea, *Forb*.......	......	....	30–45	weedy.	Syra, Naxia.	Med., Celt. Seas.
testudinaria ?, *Cuv.*	......	....	lit.	rock.	Lycia.	Celtic, North.
argo, *Lin*............	......	....	lit.	rock.	Lycia.	
aurata, *Forb*........	......	....	50	....	Cyclades.	
pilosa, *Mul*.........	......	....	13	weedy.	Cyclades.	Med., Celt., N. S.
Goniodoris, Forb. ...	?	4				
gracilis, *Rupp*......	......	....	40	weedy.	Cyclades.	
vivida, *Forb*........	......	....	8–28	weedy.	Cyclades.	
tenerrima, *Forb*. ...	......	....	40	weedy.	Cyclades.	
regalis, *Forb*.	......	....	lit.	....	Skanousi.	
Tethys, Lin............	2	1				
leporina, *Lin*.	......	....	pelagic.	....	G. of Smyrna.	Mediterranean.
Tritonia, Cuv.	......	1				
plebeia, *Johnst*......	......	....	25	mud and corallines.	G. of Smyrna.	Med., Celt. Seas.
Scyllæa, Lin.	1	1				
pelagica, *Lin*.	......	....	4	zostera.	Milo.	Mediterranean.
Melibœa, Rang	?	2				
coronata, *Gm*.?......	......	....	30	mud and corallines.	G. of Smyrna.	Med., Celt. Seas.
? minuta, *Forb*......	......	....	5	weed.	Despotico.	
Eolida, Cuv...........	?	1				
embletoni, *Johnst*. ?	......	....	lit.	stony.	Paros.	
Elysia, Risso.						
timida, *Risso*	1	1	lit.	rocky.	Paros.	Celtic Seas.

Gasteropoda, Inferobranchiata, Tectibranchiata, Scutibranchiata, Cyclobranchiata, and Cirrhobranchiata.

Of these orders there are sixty Ægean species, among which six are Inferobranchiata, twenty-two Tectibranchiata, fifteen Scutibranchiata, eleven Cyclobranchiata, and one Cirrhobranchiata. Of the sixty species fifty-one have calcareous shells, the remainder belonging to the genera *Aplysia, Pleurobranchus*, and *Gasteropteron*. The genus *Doridium* was not met with. Of the testaceous species eight are new, four inhabiting very deep water. Of the remainder, *Bulla convoluta* has hitherto been known only in a fossil state. Thirteen species range to the British Seas. Four or five testaceous species, inhabiting the western Mediterranean, do not reach the Ægean. Associated with the *Dentalia* are several species of *tubicolar annelides* of the genus *Ditrupa*, most of them inhabiting very deep water. The slight contraction of the mouth of the shell in this curious genus enables us to distinguish between it and its molluscan analogue when the animal is absent.

Species.	Range.	Found living at	Ground.	Freq.	Geographical Distribution.
INFEROBRANCHIATA.	fathoms.	fathoms.			
Pleurobranchus, Cuv.					
aurantiacus, *Risso*	40	40	weedy.	v. r.	
limacoides, *Forb.*	lit.	lit.	rocky.	r.	
scutatus, *Forb.*	20	20	weedy.	v. r.	
calyptræoides, *Forb.*	20	20	weedy.	v. r.	
sordidus, *Forb.*	40	40	weedy.	v. r.	
Umbrella, Lam.					
mediterranea, Lam.	70	0	nullipore.	v. r.	
TECTIBRANCHIATA.					
Aplysia, Lin.					
depilans? *Lin.*	5–7	5–7	mud.	f.	Lus., Celt., N.
depressa, *Cantr.*	5–15	5–15	mud.	l., r.	
saltator, *Forb.*	12–30	12–30	weedy.	l., r.	
Icarus, Forb.					
gravesi, *Forb.*	10–25	10–25	weedy.	l.	
Bullæa, Lam.					
aperta, *Lin.*	29–110	29	weedy.	l.	Lus., Celt., N.
angustata? *Bivon.*	lit.–119	0	mud.	v. r.	
alata, *Forb.*	119	0	mud.	v. r.	
Bulla, Lin.					
lignaria, *Lin.*	40	0	nullipore.	v. r.	Lus., Celt., N.
retifer, *Forb.*	20	0	weedy.	v. r.	
akera, *Mul.*	20	0	weedy.	v. r.	Lus., Celt., N.
hydatis, *Lin.*	6–30	10	mud.	l.	Lus., Celt., N.
cornea, *Lam.*	0–69	20–55	mud.	a.	
striata, *Brug.*	1	1	mud.	l.	
utriculus, *Broc.*	40–140	0	mud, nullipore.	l.	
convoluta, *Broc.*	20–50	25–40	weed.	r.	
turgidula, *Forb.*	10	0	mud.	v. r.	
cretica, *Forb.*	120	0	mud.	v. r.	
truncata, *Adams*	13–40	0	mud.	l.	Celt., N.
truncatula, *Brug.*	7–40	10–40	sand, mud, &c.	a.	
striatula, *Forb.*	7–30	10	mud.	f.	
Gasteropteron, Meckel.					
meckelii, *Kosse*	25–30	25–30	mud.	v. r.	
Volva, Montf.					
? acuminata, *Brug.*	40	0	weed.	v. r.	
SCUTIBRANCHIATA.					
Haliotis, Lin.					
lamellosa, *Lam.*	lit.	lit.	rock.	l.	
Crepidula, Lam.					
fornicata, *Lin.*	lit.?	0	......	l.	
unguiformis, *Lam.*	10–20	10–20	shelly.	f.	Senegal.
Calyptræa, Lam.					
sinense, *Lin.*	7–55	7–40	shelly.	l.	Lus., Celt., N. [Eux.

Species.	Range.	Found living at	Ground.	Freq.	Geographical Distribution.
Capulus, De Montf.	fathoms.	fathoms.			
ungaricus, *Lin.*	105	0	nullipore.	v. r.	Lus., Celt., N.
Emarginula, Lamk.					
cancellata, *Phil.*	100	0	nullipore.	v. r.	
elongata, *Costa*	40–100	40	nullipore.	f.	Can.
huzardii, *Payr.*		0			
capuliformis, *Phil.*	40–95	40	nullipore.	r.	
Fissurella, Brug.					
neglecta, *Desh.*	lit.	lit.	rock.	a.	
græca, *Lin.*	14–95	24	weed, &c.	f.	Lus., Celt., N.
gibba, *Phil.*	lit.	lit.	rock.	a.	
Lottia, Gray.					
gussoni, *Costa*	41–69	0	nullipore.	r.	
unicolor, *Forb.*	55–150	60–105	nullipore.	f.	
Gadinia, Gray.					
garnoti, *Payr.*	lit.?	0	......	r.	
CYCLOBRANCHIATA.					
Patella, Lin.					
scutellaris, *Lam.* } ferruginea, *Gm.* } bonnardi, *Payr.* } lusitanica, *Gm.* }	lit.	lit.	rock.	a.	Can.
Chiton, Lin.					
squamosus, *Lin.*	lit.	lit.	rock.	a.	
freelandi, *Forb.*	30–50	30–50	nullipore.	r.	
cajetanus, *Bl.*	lit.	lit.	rock.	l.	
rissoi, *Payr.*	5–10	5–10	stony.	r.	
polii, *Phil.*	4	4	stony.	r.	
lævis, *Penn.*	31–80	31–80	nullipore.	l.	Lus., Celt., N.
fascicularis, *Lin.*	lit.	lit.	stony.	l.	Lus., Celt., N., [Can.
CIRRHOBRANCHIATA.					
Dentalium, Lin.					
9-costatum, *Lam.*	4–150	7–70	weed, &c.	a.	Lus.
multistriatum?, *Desh.*	7–10	0	weed, &c.	r.	
entalis, *Lin.*	1–16	7	weed, &c.	r.	Lus., Celt., N.
fissura, *Lam.*	10	0	......	v. r.	
rubescens, *Desh.*	20–28	20–25	weed.	l.	
quinquangulare, *For.*	80–230	150–230	mud.	a.	

Note.—The figures in the first column of the above and following tables indicate the extent of the range at which the species was met with, whether alive or dead; in the second, the greatest and least depth at which it was taken alive; in the third, the kind of sea-bottom is named; in the fourth, the letters express the degree of frequency of occurrence :—a, *abundant*, generally distributed and plentiful; f, *frequent*; l, *local*, more or less plentiful in a few localities; r, *rare*; and v. r, *very rare*, when but few examples occurred. In the fifth column, the extra-Mediterranean distribution (as far as known *with certainty*) is given, the European seas being divided into *Arctic, Northern, Celtic, Lusitanian*, and *Euxine*. The abbreviation "Can." refers to the seas of the Canary Islands.

Gasteropoda Pulmonifera.

A single marine species of this order, *Auricula myosotis* of Draparnaud, is found under stones in muddy places on the shores of several of the Cyclades, and also, though local, on the coast of Asia Minor. It ranges to the shores of Britain.

Gasteropoda Pectinibranchiata.

One hundred and ninety species inhabit the Ægean. Of these ninety-eight are Holostomatous univalves, eighty-two Siphonostomatous, and ten Convolute. There are among them thirty-four new species, one-half of which inhabit great depths. More than two-thirds of the Holostomata do not range beyond fifty fathoms in depth, whilst of the Siphonostomatous and Convoluted univalves more than half the species exceed that limit. Of the first division, twenty-two species extend their range to the British shores, ten of the second, and two of the third. Eight species of pectinibranchiate univalves now living in the Ægean have hitherto been observed only in a fossil state. Two of them, viz. *Fusus crispus* and *Buccinum semistriatum*, have long been regarded as characteristic shells of certain tertiary formations.

Of species recorded as inhabitants of the western Mediterranean which were not met with in the eastern, there are twenty-four Holostomata, twenty Siphonostomata, and nine Convolute.

Nearly a third of the following one hundred and ninety Pectinibranchiata are found fossil in the pliocene deposits of the Archipelago, mingled with species of a more southern character, some of which, as *Terebra duplicata* and *Phorus agglutinans*, are existing inhabitants of the Red Sea. In the corresponding tertiaries of Sicily, Atlantic species occur of which there are no traces either recent or fossil in the Egean. These facts would seem to indicate the connexion of a Mediterranean basin on the one hand with the Indian Ocean by the Red Sea, and on the other with the Celtic Seas during the last tertiary period.

Pectinibranchiata.

Species.	Range.	Found living at	Ground.	Freq.	Geographical Distribution.
Coriocella, Blainv.	fathoms.	fathoms.			
perspicua, *Gmel.* ..	69	0	....	v. r.	Lus., Celt.
Natica, Brug.					
millepunctata, *Lam.*	10–70	0	weedy.	l.	Lus.
valenciensii, *Payr.* .	10–60	10	weedy.	l.	
pulchella, *Risso*.. ...	2–80	20–45	weedy, nullipore	f.	
guilleminii, *Payr*...	13–20	0	....	r.	
olla, *M. de Serres*..	4–10	4–7	sand.	l.	
Eulima, Risso.					
polita, *Mont*....... ..	7–29	......	sand.	f.	Lus., Celt., N.
distorta, *Desh.*	69–140	......	weedy.	l.	Can.
nitida, *Lam.*	25–41	41	weedy, nullipore	l.	
subulata, *Don.*	7–140	29	weedy.	l.	Celt., N.
unifasciata, *Forb.* ...	69	......	nullipore.	v. r.	
Parthenia, Lowe.					
acicula, *Phil*.........	10–41	30	weedy.	l.	
pallida, *Phil*.........	41	0	......	v. r.	

Species.	Range.	Found living at	Ground.	Freq.	Geographical Distribution.
Parthenia, Lowe.	fathoms.	fathoms.			
ventricosa, *Forb.* ...	110–150	0	mud.	f.	
turris, *Forb.*..	......	......	......	v. r.	
elegantissima, *Mon.*	4–31	10–31	mud.	a.	Celt., N., Can.
scalaris, *Phil.*.	30	0	nullipore.	v. r.	
fasciata, *Forb.*	110–150	0	mud.	v. r.	
varicosa, *Forb.*......	29	0	weed.	v. r.	
humboldti, *Riss.* ...	lit.?	0	sand.	l.	
Odostomia, Flem.......					
conoidea, *Broc*......	7–41	35–40	sand, weed.	f.	
Truncatella, Risso ...					
truncatula, *Drap*....	lit.	lit.	sand.	l.	Lus., Celt.
Rissoa, Frem.					
desmaresti, *Forb.* ...	10	10	mud.	a.	
(= costata, *Desm.*)					
ventricosa, *Desm*....	10–80	10–80	mud, weed, sand.	a.	Lus., Celt.
oblonga, *Desm*.......	10	10	mud.	l.	Lus.
violacea, *Desm*	7–16	7–16	mud.	l.	Lus., Celt.
monodonta, *Bivon*..	sublit.	sublit.	sand?	l.	
radiata, *Phil*........	10	10	mud.	v. r.	
rubra, *Adams*.	sublit.	sublit.	sand.	l.	Lus., Celt., N.
cancellata, *Desm*. ...	sublit.	sublit.	sand.	f.	Lus.
cimicoides, *Forb.* ...	2–69	4–29	sand, weed.	f.	
granulata, *Phil*......	19	sublit.	sand.		
montagui, *Payr.* ...	10–29	10	sand, weed.	a.	
buccinoides? *Desh*..	4	4	mud.	r.	
reticulata, *Mont.* ...	30–185	55	nullipore, mud.	a.	Celt., N.
ovatella, *Forb.*	69–150	0	mud.	r.	
acuta, *Desm*....	4–110	0	weed, mud.	r.	Lus.
pulchella, *Phil*.......	10–31	10–31	weed, &c.	f.	
conifera, *Mont*.......	10	sublit.	sand.	a.	Celt.
striata, *Adams*.......	20	0	nullipore.	v. r.	Celt., N.
cingilus, *Mont.*	20	0	nullipore.	v. r.	Celt., N.
pulchra, *Forb.*	lit.	0	sand.	v. r.	
elongata, *Phil.*	25	0	nullipore.	r.	
Littorina, Fer.					
cœrulescens, *Lin.* ...	lit.	lit.	rock.	a.	General in N. & S. Atlantic, [Eux.
Fossarus, Phil.					
adansoni, *Phil.*	lit.	lit.	rock.	r.	
Scalaria, Lam.					
communis, *Lam.* ...	10	10	mud.	l.	Lus., Celt., N.
lamellosa, *Lam.* ...	sublit.?	0	sand.	l.	Lus., Can.
planicosta, *Bivon* ...	45	0	nullipore.	r.	
hellenica, *Forb*......	110	0	mud.	v. r.	
Turritella, Lam.					
triplicata, *Broc*.......	6–95	30–69	mud, &c.	a.	Can.
terebra, *Lin*.........	7–60	7–60	mud.	l.	Lus., Celt., N.
suturalis, *Forb.*	25	0	mud.	v. r.	
Vermetus, Adanson					
gigas, *Bivon*.........	sublit.	sublit.	rock, &c.	a.	
sublamellatus, *Bivon*	lit.	lit.	rock, &c.	a.	

Species.	Range.	Found living at	Ground.	Freq.	Geographical Distribution.
	fathoms.	fathoms.			
Vermetus, Adanson.					
arenarius, *Desh.* ...	lit.	lit.	rock, &c.	a.	
glomeratus, *Lin.* ...	lit.	lit.	rock, &c.	f.	
granulatus, *Forb.* ...	lit.	lit.	rock, &c.	f.	
corneus, *Forb.*	25–48	40–45	weedy.	l.	
Siliquaria, Brug.					
anguina, *Gmel.* ...	45–69	0	nullipore.	r.	
Nerita, Lin.					
viridis, *Lin.*	4–24	4–16	weedy.	l.	West Indies.
Adeorbis, S. Wood.					
subcarinata, *Mont* ...	lit.	0	sand?	f.	Lus., Celt.
Scissurella, D'Orb.					
plicata, *Phil.*	70–150	0	mud.	r.	
Solarium, Lam.					
stramineum, *Gmel.*	69	0	nullipore.	l. r.	
Trochus, Lin.					
coutourii, *Payr*	15–69	69	weed.	a.	Eux.
viellоti, *Payr.*	lit.	lit.	rock.	f.	
jussieui, *Payr.*	lit.	lit.	rock.	a.	
tineis, *Chacci.*	69–105	0	nullipore.	l.	
magus, *Lin.*	25–40	25	weedy.	l.	Lus., Celt., N., [Can.
canaliculatus, *Lam.*	6–13	6–8	weedy.	l.	
racketti, *Payr.*	4–14	sublit.	mud.	f.	
villicus, *Phil.*	14	14	mud.	r.	
pallidus, *Forb.*	lit.	0	rock?	v. r.	
umbilicaris, *Gmel.* .	lit.	lit.	rock.	l.	Lus.
lyciacus, *Forb.*	lit.	lit.	rock.	l.	
spratti, *Forb.*	3–30	3–24	weed.	a.	
fanulum, *Gmel*	9–60	9	weed.	l.	
richardi, *Payr.*	lit.	lit.	rock.	l.	
adansoni, *Payr.* ...	3–30	3–20	weed.	f.	
divaricatus, *Lin.* ...	lit.	lit.	rock.	a.	Eux.
articulatus, *Lam.* ...	lit.	lit.	rock.	a.	
fragarioides, *Lam* ...	lit.	lit.	rock.	a.	Lus., Can.
therensis, *Forb*	lit.	lit.	rock.	l.	
ziziphinus, *Lin.* ...	19–55	19–55	weed.	f.	Lus., Celt., N.
conulus, *Lam.*	8–27	8–27	mud, weed.	f.	Lus.
laugieri, *Payr.*	sublit.?	0	sand?	l.	Lus.
crenulatus, *Broc.* ...	3–10	3–10	sand, mud, &c.	a.	Lus.
gravesi, *Forb.*	3–41	8–40	sand, weed.	a.	
exasperatus, *Penn.* .	10–165	10–105	mud, nullip., &c.	a.	Lus., Celt.
millegranus, *Phil.* .	41–110	41–110	mud, nullipore.	r.	Lus., Celt., N.
Turbo, Lin.					
sanguineus, *Gmel.* ...	27–105	27–60	nullipore.	f.	
rugosus, *Gmel.*	8–80	8–80	mud, weed.	l.	Can.
Phasianella, Lam.					
pulla, *Gmel.*	2–80	3–80	sand.	f.	Lus., Celt., N. [Eux., Can.
intermedia, *Phil.* ...	8–10	8–10	mud.	l.	
vieuxii, *Payr.*	6–24	6–24	sand, &c.	f.	
Ianthina, Lam.					
nitens, *Menke.*	pelagic.	pelagic.	......	l.	Atlantic.

Species.	Range.	Found living at	Ground.	Freq.	Geographical Distribution.
Cerithium, Brug.	fathoms.	fathoms.			
vulgatum, *Brug.* ...	11–40	11–40	mud, weed.	a.	Eux., Can.
fuscatum, *Costa.* ...	lit.	lit.	rock.	a.	
mammillatum, *Risso.*	lit.	lit.	sand.	l. a.	
lima, *Brug.*	3–140	3–80	weed, &c.	a.	Lus., Celt., N., [Can.
trilineatum, *Phil.*...	lit.?	0	sand?	r.	
lacteum, *Phil.*	29–30	0	nullipore.	r.	
angustissimum, *Forb.*	7–55	0	weed.	l.	
Triforis, Desh.					
adversum, *Lin.*	4–95	7–41	weed.	f.	Lus., Celt.
perversum, *Lam.* ...	55–69	69	weed.	l.	Lus., Celt., Can.
Pleurotoma, Lam......					
albida, *Desh.*.........	lit.?	0	sand?	f.	
formicaria, *Sow.* ...	10–80	10–80	weed.	a.	Peru?
rude, *Phil.*	lit.?	0	sand?	r.	
crispata, *Jan.*	40–105	70–80	mud, sand.	l.	
bertrandi, *Payr.* ...	13	0	weed.	r.	
purpurea, *Mont.*. ...	30–50	35	weed.	l.	Lus., Celt., N.
reticulata, *Bron.* ...	20–105	30	weed.	l.	Lus.
β spinosa, *Forb.* ...	3–55	3–40	weed, &c.	a.	
maravignæ, *Biv.* ...	20–105	20–80	weed, &c.	f.	
vauquelini, *Payr.*..	24–55	31	gravel.	l.	
gracilis, *Mont.*	13–80	50–80	nullipore.	f.	Lus., Celt.
attenuata, *Mont*......	7–35	8–31	weed.	l.	
lævigata, *Phil.*	8	0	sand.	v. r.	
teres, *Forb.*	45	0	nullipore.	v. r.	
lefroyi, *Mich.*					
philberti, *Mich*......	20–55	24–31	weed, &c.	f.	
turgida, *Forb.*	25–30	30	weed.	r.	
fallax, *Forb*.........	......	......	......	r.	
linearis, *Mont.*	8–31	8	weed.	l.	Lus., Celt., N.
fortis, *Forb.*	70	0		v. r.	
lyciaca, *Forb.*	80			v. r.	
minuta, *Forb.*	92–105			r.	
abyssicola, *Forb.* ...	110			r.	
ægeensis, *Forb.*......	13	13	weed.	v. r.	
Fasciolaria, Lam.					
tarentina, *Lam.*......	lit.	lit.	rock.	a.	
Fusus, Lam.					
lignarius, *Lam.*......	lit.–30	lit.–7	rock, mud.	a.	
syracusanus, *Lam.* .	3–41	3–41	sand.	l.	
lavatus, *Bast.*	10–60	10–60	mud, weed.	a.	Lus.
muricatus, *Mont*. ..	50–150	80–95	nullipore, &c.	f.	Lus., Celt., N.
crispus, *Broc.*	40–60	0	nullipore.	f.	
fasciolarioides, *Forb.*	20–58	23–30	weed.	f.	
karamanensis, *Forb.*	30	30	mud.	v. r.	
Murex, Lin.					
brandaris, *Lin.*	2–40	3–28	sand, mud, &c.	a.	Can.
trunculus, *Lin.*......	lit. 10–28	lit.–10	rock, mud.	a.	Can.
cristatus, *Broc.*......	20–80	50–80	sand, weed.	a.	
edwardsii, *Payr.* ...	lit.	lit.	rock.	a.	

Species.	Range.	Found living at	Ground.	Freq.	Geographical Distribution.
	fathoms.	fathoms.			
Murex, Lin.					
vaginatus, *Cr.&Jan.*	150	0	mud.	v. r.	
distinctus, *Cr. & Jan.*	40–69	0	nullipore.	r.	
brevis, *Forb.*.........	24	24	mud.	v. r.	
fistulosus, *Broc*......	6–50	6	mud.	r.	
Aporrhais, Da Costa.					
pes-pelecani, *Lin*....	12–70	20–45	weed, mud.	a.	Lus., Celt., N.
Ranella, Lam.					
lanceolata, *Menke*....	lit. ?	0	rock ?	v. r.	
Triton, Lam.					
variegatum, *Lam*....	7	7	weed.	v. r.	
Purpura, Lam.					
hæmastoma, *Lam*. .	lit.	0	rock.	v. r.	Atlantic.
Cassidaria, Lam.					
tyrrhena, *Lin*.	40–48	0	weed.	v. r.	
Dolium, Lam.					
galea, *Lin*............	10–31	0	sand ?	l.	Can.
Pollia, Gray.					
maculosa, *Lam*......	lit.	lit.	rock.	a.	
candidissima, *Phil*..	lit.	0	sand ?	v. r.	
minima, *Phil*.	55–69	60	nullipore.	l.	
Nassa, Lam.					
macula, *Mont*.	7–10	9	weed.	v. r.	Lus., Celt., N.
variabile, *Phil*	0–27	0–7	mud.	a.	
d'orbignyi, *Payr*....	lit. ?	0	sand ?	r.	
varicosa, *Turt*.	27	0	....	r.	
intermedia, *Forb*....	45–185	0	nullipore, mud.	l.	
granulata, *Phil*......	7–10	0	mud.	r.	
prismatica, *Broc*. ...	19–20	0	nullipore.	r.	
reticulata, *Lin*......	7–10	7	weed.	a.	Eux., Can.
musiva ?, *Broc*......	7–10	8	weed.	l.	Lus.,Celt.,Brit.
cornicula, *Olivi*. ...	0–19	2	rock, &c.	l.	
semistriata, *Broc*....	70–78	0	mud.	v. r.	
mutabile, *Lin*.	lit.–10	lit.–10	sand, mud.	a.	Lus., Can.
gibbosula, *Lin*.	lit.	0	sand ?	v. r.	
neritea, *Lin*.	lit.	lit.	sand.	a.	Lus., Eux.
Columbella, Lam.......					
rustica, *Lam*.........	0–55	lit.–20	rock, &c.	a.	Eux., Can.
linnæi, *Payr*.........	lit.–60	lit.–10	rock, &c.	a.	Eux.
gervillii, *Payr*.......	30–40	30	weed.	l.	
Mitra, Lam.					
ebenus, *Lam*.	20–80	20–80	weed, mud.	f.	Can.
cornea, *Lam*..........	lit. ?	0	weed.	l.	
savignii, *Payr*.......	16–30	16–20	weed.	f.	
obsoleta, *Bron*.......	3–69	6–30	weed.	f.	
littoralis, *Forb*.......	lit.	0	sand ?	a.	
phillippiana, *Forb*. .	45–105	45	nullipore.	r.	
granum, *Forb*.	20–60	20	weed.	l.	
Tornatella, Lam.					
fasciata, *Lam*.	29–80	80	sand.	l.	Lus., Celt., N.
pusilla, *Forb*.........	100	0	nullipore.	v. r.	

Species.	Range.	Found living at	Ground.	Freq.	Geographical Distribution.
Tornatella, Lam.	fathoms.	fathoms.			
globulina, *Forb.* ...	95	0	nullipore.	v. r.	
Marginella, Lam.					
clandestina, *Bron.*..	4–105	10–40	mud, &c.	a.	
secalina, *Br.*.........	25–69	30	weed.	l.	
miliacea, *Lam.*......	lit.–20	0	sand.	f.	
Erato, Risso.					
lævis, *Don*	19–55	40–45	weed, nullip.	l.	Lus., Celt.
Ringuicula, Desh.					
auriculata, *Menard.*	7–10	0	sand?	r.	Can.
Cypræa, Lin.					
lurida, *Lin.*	lit.	0	sand?	v. r.	
pyrum, *Lin.*	lit.	0	sand?	v. r.	
spurca, *Lin.*	lit.	lit.	rock.	l.	
europæa, *Lin.*	23–60	55	nullipore.	f.	Lus.
Conus, Lin.					
mediterraneus, *Brug.*	2–41	lit.–10	rock, mud.	a.	Eux.

Palliobranchiata.

Eight species of *Brachiopoda* inhabit the Ægean, seven of which are *Terebratulæ* and one a *Crania*. They range from 25 to 230 fathoms, but abound between 70 and 100 on a bottom of nullipore and coral, where the number of individuals belonging to this tribe taken in a single dredge usually far exceeds that of all the other Testacea accompanying them. Their presence and abundance is an unfailing clue to the region from whence the produce of the dredge has been obtained. They are gregarious, living on clean ground, and were found only in a dead state in the neighbouring mud. Of the largest species, the *Terebratula vitrea*, two broken specimens only were taken, one of them at the great depth of 1380 feet below the surface. No living examples of any of the species, however, were found below 105 fathoms. The uniform muddy bottom below that depth is unfavourable to their presence. The same remarks apply to *Crania ringens*. It is remarkable that *Terebratula caput serpentis*, which is not uncommon in the western Mediterranean, is altogether absent in the eastern. *Thecidia*, also, was never met with in the latter.

Species.	Range.	Found living at	Ground.	Freq.	Geographical Distribution.
Terebratula, Lam. ...	fathoms.	fathoms.			
vitrea, *Gm.*	92–250	0	nullip., mud.	v. r.	N. Atlantic.
truncata, *Gm.*	55–105	60–105	nullipore.	a.	North., Lus., [Can.
detruncata, *Gm.* ...	27–110	45–105	nullipore.	a.	
cuneata, *Risso*.......	28–69	28–69	nullipore.	r.	
lunifera, *Phil.*	95	95	nullipore.	v. r.	
seminulum, *Phil.* ...	45–105	60–105	nullipore.	f.	
appressa, *Forb.*......	95	95	nullipore.	v. r.	
Crania, Retz.					
ringens, *Honing.* ...	40–150	40–90	nullipore.	a.	

Lamellibranchiata Dimyaria.

One hundred and fifteen species of this division of bivalve Mollusca were observed in the Ægean. Of these ten are undescribed forms, most of which are inhabitants of great depths. Two are species formerly known only in the fossil state (*Solen tenuis* and *Neæra costellata*). Forty-five extend their range to the British shores; six do not reach beyond the oceanic coasts of the peninsula. Of the more abundant larger forms, the greater part are littoral species; among the smaller deep sea forms some, such as *Ligula profundissima* and *Kellia abyssicola*, are very abundant. The majority of species in this division inhabit muddy or sandy ground.

None of the new species found were observed fossil in the neighbouring tertiaries. Among the pleiocene fossils were four species, which, though three of them are not unfrequent in the western Mediterranean, were not met with in the eastern (*Isocardia cor*, *Pholas candidus*, *Artemis exoleta*, and *Venus casina*). It is worthy of remark that these are all existing Celtic forms. Neither was *Diplodonta apicalis* met with alive, which is abundant in the tertiaries of the Archipelago, and is an existing inhabitant of the Red Sea. There are thirty-seven species inhabiting the coasts of Sicily which were not met with in the Ægean; of these twenty-two are oceanic forms.

Lamellibranchiata Dimyaria.

Species.	Range.	Found living at	Ground.	Freq.	Geographical Distribution.
	fathoms.	fathoms.			
Teredo, sp.	119	0		v. r.	
Clavagella, Lam.					
melitensis?	lit.	lit.	calc. rock.	l.	
Gastrochæna, Speng.					
cuneiformis, *Lam*...	30	0	mud.	v. r.	
Solen, Lin.					
siliqua, *Lin*.	1	0	sand.	r.	Lus., Brit.
tenuis, *Phil*.	7–40	7–40	sandy & nullip.	r.	
coarctatus, *Lin*.......	7–50	20	nullipore.	f.	Celt., N.
Solecurtus, De Bl.					
strigillatus, *Lin*. ...	1	½–1	sand.	l.	Celt.
Ligula, Mont.					
sicula, *Sow*.	lit.	0	sand.	r.	
boysii, *Mont*.........	4–50	10–45	mud.	a.	Celt., N.
prismatica, *Mont*....	25–55	55	mud.	r.	Northern.
*profundissima, *Forb*.	72–30	80–185	white mud.	a.	
Mactra, Lin.					
stultorum, *Lin*.......	lit.	lit.	sand.	l.	Celt., N., Lus.
Kellia, Turt.					
corbuloides, *Phil*....	lit.	lit.	sand.	l.	
suborbicularis, *Mont*.	29–45	30–55	mud.	r.	Celt., N.
rubra, *Mont*.........	lit.	lit.	rock.	l.	N. & S. Atl.
abyssicola, *Forb*. ...	70–200	70–180	mud.	a.	
transversa, *Forb*. ...	119	0	white mud.	v. r.	
Montacuta, Turt.					
sp. und...............	7	0	mud.	v. r.	
Solenomya, Lam.					
mediterranea, *Lam*.	2	0	sand.	v. r.	
Byssomya, Payr.					
guerinii, *Payr*.. ...	8	0	sand.	v. r.	

Species.	Range.	Found living at	Ground.	Freq.	Geographical Distribution.
Corbula, Lam.	fathoms.	fathoms.			
nucleus, *Lam.*	7–80	7–40	mud, sand.	a.	Lus., Celt., N.
Poromya, Forb.					
anatinoides, *Forb.*...	40–150	0	mud.	f.	
Neæra, Gray.					
cuspidata, *Bron.* ..	12–185	12–185	mud, weed, sand.	f.	Lus., Celt., N.
costellata, *Desh.* ...	20–185	30–185	mud, grav. weed.	f.	
attenuata, *Forb.* ..	110–150	140	mud.	r.	
abbreviata, *Forb.* ...	75–185	140	mud.	r.	
Pandora, Lam.					
rostrata, *Lin.*	4	0	sand.	v. r.	Lus., Celt.
obtusa, *Leach.*	7–110	20–70	mud, weed.	f.	Lus., Celt.
Lyonsia, Turt.					
striata, *Mont.*	20–70	20–70	weed, nullip.	l.	Lus., Celt., N.
Thracia, Leach.					
pubescens, *Mont.* ...	70	0	....	v. r.	Lus., Celt., N.
phaseolina, *Kiener.*	7–30	7	sand.	v. r.	
pholadomyoides, *For.*	150	0	coral.	v. r.	
Saxicava, Lam.					
arctica, *Fabr.*	20–80	20–80	weed, sand.	l.	Lus., Celt., N., [Can.
Venerupis, Lam.					
Irus, *Lam.*...........	lit.	0	....	a.	Lus., Celt., N., [Eux.
decussata, *Phil.*.....	lit.	0	sand ?	a.	
Psammobia, Lam.					
vespertina, *Lam.* ...	7–40	0	sand.	r.	Lus., Celt., Can.
discors, *Lam.*	25–40	0	nullipore.	v. r.	
ferroensis, *Mont.* ...	20–40	0	nullipore.	v. r.	Lus., Celt., N.
Tellina, Lin.					
pulchella, *Lam.*.....	11	0	sand ?	r.	[Eux.
donacina, *Gm.*	7–45	7–12	mud.	a.	Lus., Celt., N.,
serrata, *Broc.*	7–45	0	weed.	l.	
balaustina, *Poli* ...	6–48	40	sand.	f.	
fragilis, *Lin.*	lit.	0	sand.	r.	Lus., Celt., Eux.
planata, *Lin.*.........	lit.	0	sand.	l.	Lus
depressa, *Gm.*	lit.	0	sand.	l.	Lus., Celt.
distorta, *Poli*	5–10	7	weed.	l.	
Lucina, Brug.					
flexuosa, *Mont.*......	7–11	11	mud.	r.	Celt.
lactea, *Lam.*	0–25	10–24	mud.	a.	Lus., Celt., Eux. [Can.
desmarestii, *Payr.* .	lit.	lit.	sand.	l.	
rotundata, *Mont.*....	6	0	mud.	r.	Celt.
spinifera, *Mont*	4–30	13–40	weed, nullipore.	f.	Lus., Celt.
pecten, *Lam.*.........	0–16	0	sand.	f.	Can.
digitalis, *Lam.*	25	0	sand ?	v. r.	Lus., Celt.
commutata, *Phil.*...	11–75	0	nullipore.	l.	
bipartita, *Phil.*	55–95	69	nullipore.	l.	
transversa, *Bronn* ...	10–25	10	mud.	f.	
ferruginosa, *Forb.*...	119	119	mud.	l.	
Donax, Lin.					
trunculus, *Lin.*......	lit.	lit.	sand.	l.	Lus., Celt., N. [Eux., Can.
venusta, *Poli*	8	8	mud.	r.	
complanata, *Mont.* .	lit.	lit.	sand.	l.	Lus., Celt.

Species.	Range.	Found living at	Ground.	Freq.	Geographical Distribution.
Donax, Lin.	fathoms.	fathoms.			
semistriata, *Poli* ...	lit.	0	sand.	r.	
Mesodesma, Desh.......					
donacilla, *Desh*.......	lit.	½	sand.	a. l.	Lus.
Astarte, Sow.					
incrassata, *DelaJonk.*	30–80	......	nullipore.	r.	
pusilla, *Forb.*	70–112	70	nullipore.	l.	
Artemis, Poli.					
lincta, *Mont*..........	0–16	1	sand.	l.	Lus., Celt., N.
Cytherea, Lam.					
apicalis, *Phil.*	4–95	30–40	weed, coral.	a.	
venetiana, *Lam*......	20–40	0	mud.	f.	
chione, *Lin.*	7–10	0	....	r.	Lus., Celt.
Venus, Lin.					
gallina, *Lin.*	0–2	1–2	sand.	l.	Lus., Celt., N., [Eux. & Casp.
verrucosa, *Lin*.......	2–40	0	......	l.	Lus., Celt., Can.
ovata, *Mont*..........	29–135	27–80	nullipore, mud.	a.	Lus., Celt., N.
fasciata, *Mont.*	27–40	40	nullipore.	l. r.	Lus., Celt., N.
incompta? *Phil.* ...	20–30	0	......	r.	
Pullastra, Sow.					
virginea, *Lin.*	15	0	weed.	r.	Lus., Celt., N.
aurea, *Lin*...........	4–10	7	mud.	l.	Lus., Celt.
geographica, *Lin*....	10–15	10	mud.	l.	Lus.
decussata, *Lin*.......	lit.	lit.	sand.	f.	Lus., Celt.
Cardium, Lin.					
echinatum, *Lin*......	7–50	0	weed.	l.	Lus., Celt., N.
erinaceum, *Lam.* ...	20	0	weed.	v. r.	
lævigatum, *Lin*......	20–40	0	weed.	l.	Lus., Celt., N.
papillosum, *Poli* ...	6–75	7–45	weed, mud, &c.	a.	
exiguum, *Lin.*	7–30	16–24	weed.	f.	Lus., Celt.
punctatum, *Ren.* ...	12	12	sand.	r.	
minimum, *Phil*.......	70–142	80	mud	f.	
edule, *Lin*...........	lit.	lit.	sand.	l.	Lus., Celt., N., [Eux., Casp., [Can.
rusticum, *Chemn*....	lit.	lit.	sand.	r.	Lus., Eux., [Casp.
Cardita, Brug.					
sulcata, *Brug.*	7–30	10–20	weed.	f.	
squamosa, *Lam.* ...	25–150	40–95	nullipore.	f.	
trapezia, *Mull.*	0–95	1–25	rock, weed.	f.	
calyculata, *Lam.* ...	0–1	0–½	rock.	a.	Lus., Can.
Arca, Lin.					
barbata, *Lin*.........	lit.–4	0–1	rock.	a.	Lus., Celt.
lactea, *Lam.*	0–150	10–150	r^k., weed, nul. &c.	a.	Lus., Celt.
scabra, *Poli*	70–105	100	nullipore.	r.	
imbricata, *Poli* ...	35–230	90–230	nullipore, mud.	f.	Can.
antiquata, *Lin*.......	45–50	0	nullipore.	r.	
tetragona, *Poli*	20–80	30–80	nullipore.	f.	Lus., Celt.
noæ, *Lin.*	0–27	1–3	rock.	f.	Lus., Can.
Pectunculus, Lam.					
glycimeris, *Lam.* ...	6–24	6	mud.	r.	
pilosus, *Lam*.........	25–69	69	nullipore.	r.	Lus., Celt., N., [Can.
violaceus, *Lam*......	10	0	gravel.	v. r.	
lineatus, *Phil.*	4–30	0	nullipore.	r.	

Species.	Range.	Found living at	Ground.	Freq.	Geographical Distribution.
Nucula, Lam.	fathoms.	fathoms.			
polii, *Phil.*	45–140	0	mud, nullipore.	l.	
margaritacea, *Lam.*	2–95	3–40	mud, &c.	a.	Lus., Celt., N.
ægeensis, *Forb.*	185	185	mud.	r.	
emarginata, *Lam.*	7–50	7–45	mud, weed.	f.	
striata, *Phil.*	40–185	40–11	sand, mud.	f.	
Chama, Lin.					
gryphoides, *Lin.*	0–50	12–0	rock, nullipore.	f.	Lus., Can.
Modiola, Lam.					
barbata, *Lam.*	7–95	7–95	mud, weed, null.	l.	Lus., Celt.
tulipa, *Lam.*	2–50	6–45	mud, &c.	l.	Lus., Celt.
discrepans, *Mont.*	10–40	10	weed.	r.	Lus., Celt., N.
marmorata, *Forb.*	19–45	19	gravel.	r.	Lus., Celt., N.
Lithodomus, Lam.					
lithophagus, *Lam.*	lit.	lit.	rock.	f.	
Mytilus, Lin.					
gallo-provincialis, [*Lam.*	lit.	lit.	rock.	r.	
minimus, *Poli*	lit.	lit.	rock.	a.	
Pinna, Lin.					
squamosa, *Lin.*	1–24	1	sand, mud.	f.	Can.

Lamellibranchiata Monomyaria.

There are twenty-eight species of this division of bivalve Mollusca inhabiting the Ægean. Of these six are undescribed forms inhabiting the greater depths, being all found between 40 and 200 fathoms. Of the remainder, eight extend their range to the shores of Britain. Many of the species which elsewhere attain a considerable size are small in the Ægean. The gregarious species do not there form great banks or beds as in other places.

Of the new species found one only (*Pecten hoskynsii*) was observed fossil in the neighbouring tertiaries, and that one in a deposit of considerable age (ante-pliocene). Of the others, several are abundant in the pleiocene deposits, at the period of the formation of which, however, they seem to have attained their full dimensions, and not to have been dwarfed as at the present day. Generally speaking, the proportion of dead valves greatly exceeds that of living shells of this section, brought up in dredge, and in the majority of species the valves become disunited after death and scattered. There are about twelve Monomyaria, which though inhabiting the western Mediterranean, do not seem to extend their range to the Ægean.

Lamellibranchiata Monomyaria.

Species.	Range.	Found living at	Ground.	Freq.	Geographical Distribution.
Avicula, Lam.	fathoms.	fathoms.			
tarentina, *Lam.*	20	20	mud.	r.	Can.
Lima, Brug.					
squamosa, *Lam.*	1–69	1–28	rock, gravel.	f.	Lus., Can.
tenera, *Turt.*	0–30	0	sand.	l.	Lus. Celt.
fragilis, *Mont.*	20–40	20–40	nullipore.	l.	Lus., Celt., N., [Can.
subauriculata, *Mont.*	15–30	0	weed.	l.	Lus., Celt., N.

Species.	Range.	Found living at	Ground.	Freq.	Geographical Distribution.
Lima, Brug.	fathoms.	fathoms.			
elongata, *Forb*.......	55–140	55	nullipore, mud.	f.	
cuneata, *Forb*.	40	0	nullipore.	r.	
crassa, *Forb*..........	70–150	0	nullipore, mud.	f.	
Pecten, Brug.					
jacobæus, *Lam*. ...	12–70	25	nullipore.	r.	Lus., Can.
dumasii, *Payr*.	70–150	0	nullipore, mud.	l.	
pes felis, *Lam*.	60–69	0	nullipore.	r.	
sulcatus, *Lam*.	7	0		l.	
opercularis, *Lin*. ...	10–70	31–55	nullipore, &c.	a.	Lus., Celt., N.
varius, *Lin*.	7–55	25–55	nullipore, &c.	f.	Lus., Celt., N.
pusio, *Lam*.	10–69	40	weed.	f.	Lus., Can.
polymorphus, *Bronn*.	8–69	28–41	weed, &c.	a.	Eux.
hyalinus, *Phil*.	6–60	6–40	sand.	a.	
testæ, *Bivon*.........	29–69	30–50	weed.	f.	
similis, *Laskey*	27–185	40–70	mud.	a.	Celt., North.
fenestratus, *Forb*....	45–140	0	mud, nullipore.	f.	
concentricus, *Forb*..	70–185	0	mud.	f.	
hoskynsii, *Forb*. ...	185–200	0	mud.	l.	
Spondylus, Lam.					
gadæropus, *Lin*. ...	½–14	1	rock.	l.	Can.
gussonii, *Costa*......	105	105	nullipore.	r.	
Ostrea, Lin.					
plicatula, *Lin*.	lit.–30	lit.	rock, &c.	l.	
cochlea, *Poli*	60–110	0	nullipore.	r.	Can.
Anomia, Brug.					
ephippium, *Lin*.....	20–40	20	weed, &c.	l.	Lus., Celt., N.
polymorpha, *Phil*....	20–140	20–30	weed, &c.	l.	Lus., Celt., N.

Mollusca Tunicata.

Of the simple Ascidians seventeen species were met with. Five of them were Pelagic species, among which *Salpa maxima* and *S. democratica* were the most abundant, especially in the spring of the year, when great numbers of them approached the surface in fine weather in the afternoon. The remainder were fixed species, chiefly belonging to the genera *Phallusia*, *Ciona*, and *Cynthia*, some of which were found as deep as fifty-five fathoms; they were most abundant between twenty and forty fathoms, generally on weedy ground. A number of compound Ascidians were also met with in similar depths of water*.

Radiata.

Arachnodermata.

There are fifty-seven species of acalephous animals recorded as inhabitants of the Mediterranean sea; but few of these occur in the Ægean. Though

* The working out of the species procured of this difficult tribe and of some of the radiate families, especially the smaller Zoophytes, demands more disposable time than the reporter's professional avocations (at present) permit; he is constrained therefore reluctantly to give only a general sketch in these departments, hoping at some future meeting to present supplementary details.

continually on the look-out for these beautiful creatures only fifteen species were met with, mostly described forms. The sheltered bays of Asia Minor and the squally seas of the Cyclades were alike unprolific; twice only were considerable numbers met with; once in the Gulf of Scopæa, where during the winter months great numbers of *Aurelia*, most species of which genus are gregarious, assembled, and once in the bay of Smyrna, where the presence of gigantic *Rhizostomæ* afforded full occupation for several days, in September 1842. In neither case were the individuals widely spread, but confined to a limited space. Besides the two species named, six other members of the order *Pulmograda* were met with in the months of July, August and December. Of the *Ciliograda*, the *Beroe forskälii* was taken in May 1841, off the island of Milo, and in company with it a single example of the *Cestum veneris*. A few days after a *Cydippe* was seen, but not taken, in the bay of Syra. Of the *Physograda*, several examples of a large *Stephanomia* were met with in the Gulf of Macri, in December, where they were seen floating a few feet below the surface, about 3 p.m. on sunny days. Of the *Diphydæ* occasional individuals were seen, probably species of *Calpe* or *Pyramis*. Of the *Cirrhigrada*, *Velella spirans* was collected by Lieut. Spratt on the shore at Rhodes, in December 1842, and *Porpita glandifera* occurred once on the sandy shore between Patara and the mouth of the Xanthus in February 1842.

We must attribute the great abundance of *Medusæ* in the western Mediterranean, as compared with their scarcity in the eastern, to the oceanic influence in the former. They abound near the gut of Gibraltar, a locality prolific in species as well as individuals. Their numbers decrease as we approach the shores of Greece. In the Ægean, as we have seen, they play an unimportant part. The few gregarious species extend their range to the Black Sea, where great herds of *Aureliæ* are not unfrequently met with. Pelagic as these animals are, there is reason to believe that the range of the species is extremely limited, and that they afford a valuable means of defining zoological provinces in the open sea.

Arachnodermata.

	No. of Ægean Sp.	No. of Medit. Sp.	Date when taken.	Locality.
PULMOGRADA.	8	29		
Rhizostoma, Cuv.	1	1		
cuvieri?, *Eschs*.....	......	......	Sept. 1842.	Bay of Smyrna.
Cephea, Peron	1	1		
tuberculata, *Macri*. .	......	8	Aug., Sept., Nov. 1842.	Cyclades, Sporades, Cervi.
Oceania, Peron	1			
cruciata, *Forsk*......	......	......	July, 1841.	Serpho Bay.
Thaumantias...........	1	1		
laxa, *Forb*...........	......	......	Aug. 1841.	Off Milo.
Aurelia, Peron	1	4		
granulata?, *Lam*. ...	......	......	Dec. 1841.	Gulf of Scopæa, Caria.
Geryonia, Peron	2	2		
nov. sp.?	......	......	Aug. 1841.	Bay of Cervi.
proboscidalis, *Forsk*.	......	......	Dec. 1841.	Gulf of Macri.
Mesonema, Eschs.	1	5		
cœlum pensile, *Mod*.	......	......	May 1841.	Off Milo.

	No. of Ægean Sp.	No. of Medit. Sp.	Date when taken.	Locality.
CIRRHIGRADA.	2	2		
Velella, Lam.	1	1		
spirans, *Forsk.*	......	......	Dec. 1841.	Rhodes.
Porpita, Lam.	1	1		
glandifera, *Lam.*	......	......	Feb. 1842.	Lycia.
PHYSOGRADA.	1	7		
Stephanomia, Peron	1	2		
contorta?, *M. Ed.*	......	......	Dec. 1841.	Gulf of Macri.
CILIOGRADA.	3	6		
Beroë, Mul.	1	1		
forskalii, *M. Ed.*	......	......	May, 1841.	Off Milo.
Cestum, Le Sueur	1	1		
veneris, *Le Sueur*	......	......	May, 1841.	Off Milo.
Cydippe, Eschs	1	1		
sp.	......	......	May, 1841.	Syra.
DIPHYDÆ.	2	9		
Pyramis, Otto	1	1		
tetragona, *Otto*	......	.....	various.	Throughout.
Calpe, Quoy & Gaim.	1	1		
pentagona, *Quoy & G.*	......	......	various.	Throughout.

Echinodermata.

Crinoidea.—The only crinoid animal inhabiting the Ægean is the common European *Comatula* (*C. rosacea*), identical in every respect with the northern examples of the species. It is local, and lives on weedy ground in from 20 to 30 fathoms water. I met it only among the Cyclades. In no instance was it found in the young or *Phytocrinus* state.

Ophiuridæ.—Eleven species of *Ophiuridæ* inhabit the Ægean, ranging from the surface to the greatest depths explored. Four of the Ægean species are identical with northern forms; viz. *Ophiura texturata* and *albida, Amphiura neglecta* and *Ophiothrix rosula.* They are all found in habitats similar to those in which they occur in the British seas. The last-named species is invariably smaller than northern individuals. Five, viz. *Pectinura vestita, Ophiura abyssicola, Ophiomyxa lubrica, Ophiopsila aranea,* and *Amphiura neglecta,* are entirely new species. Three of these new forms were found only in very deep water 100 fathoms and under, one of them, the second named, having been taken alive in 200 fathoms. One of the Ægean *Ophiuridæ* is an instance of a most extensive range, being found in all muddy bottoms between 7 and 180 fathoms, the specimens from the greatest depths exactly resembling those from the shallows.

The Euryale has not as yet been found in the eastern Mediterranean; it inhabits the Eastern and the Adriatic. Deducting synonyms from previous enumerations of the Mediterranean *Ophiuridæ* proper, my list exceeds by four species all former catalogues.

Asteriadæ.—Thirteen species of *Asteriadæ* inhabit the Ægean; of these, seven do not range deeper than ten fathoms. A Goniaster and an Asterina were the species met with in deepest water, the first coming up from 60 fathoms off Cnidus, the second ranging from 20 to 70 fathoms. Four species were identical with Celtic forms, one of them being the *Uraster glacialis*, which ranges northward to the shores of Greenland. The northern seas greatly exceed the Mediterranean in the number of species and abundance of individuals of this order. Out of the small number of *Asteriadæ* which were taken in the Ægean, one half the number occurred only as single specimens.

Echinidæ.—The extreme abundance of *Echinus lividus*, which lines the rocks a little below water-mark in most parts of the Mediterranean, is a characteristic feature of that sea. Otherwise (especially in the Ægean) *Echinidæ* are not extensively represented. The true *esculentus* has a wide range in the eastern Mediterranean, extending from Cerigo to Asia Minor, but individuals are very scarce. A small species (*E. monilis*) is abundant on nullipore ground at all depths between 15 and 100 fathoms. *Spatangi* are very rare: a few examples occurred in the sandy shores, and fragments were dredged as deep as 150 fathoms. *Spatangus purpureus*, identical with the British species, is extremely scarce in the Ægean, but more frequent, and attaining a large size in the Sicilian seas. The Mediterranean *Cidaris* is very characteristic of this sea: its spines are frequently taken, and sometimes the living animal, which dwells on coral ground, mostly in from 60 to 70 fathoms. It would appear to be gregarious.

Holothuriadæ.—The number of Ægean *Holothuriadæ* is seven, of which four belong to the typical genus of the family, the species of which are very characteristic of the Mediterranean. They all live in shallow water, attain to large size, and usually occur in great numbers. The only Celtic species observed was the *Cucumaria pentactes*, dredged in 11 fathoms off the mouth of the Hermus, and exactly resembling specimens taken in similar situations on the British coast. The *Holothuriadæ* are much more numerous in the western Mediterranean. Mud and sand are their most usual habitats.

Sipunculidæ.—Out of six Ægean species of this family, three inhabit crevices of the rocks near water-mark, two live among fuci in a muddy bottom, and one (*Syrinx nudus*), the only one which is common to the Egean and Celtic seas, is found on sand. The rock-inhabiting species are frequent, the others rare. There is no diminution in the number of individuals or their size as we travel eastwards.

Echinodermata.

Species.	Ægean.	Medit.	Ground.	Depth.	Geog. Distrib.
CRINOIDEA.				fathoms.	
Comatula, Lam.	1	1			
rosacea, *Link*	....	....	weedy.	20–30	Celtic seas.
OPHIURIDÆ.					
Pectinura, Forb.	1	1			
vestita, *Forb.*.......	....	....	nullipore.	100	
Ophiura, Lam.........	3	3			
texturata, *Lam.*......	....	....	weedy.	28	
albida, *Forb.*........	....	....	sand, weed.	5–50	Celt. & North.
abyssicola, *Forb.*	....	....	white mud.	100–200	British seas.
Ophioderma, Mul. & Tros.	1	2			
lacertosa, *Lam.*......	....	....	weedy, mud.	10–30	Can.

Species.	Ægean.	Medit.	Ground.	Depth.	Geog. Distrib.
OPHIURIDÆ.				fathoms.	
Ophiomyxa, Mul. & Tros.	1	1			
lubrica, *Forb.*	....	....	weedy.	10–20	
Ophiopsila, Forb.......	1	1			
aranea, *Forb.*........	....	....	weedy.	20–50	
Amphiura, Forb.	3	5?			
florifera, *Forb.*	....	....	mud.	100	
neglecta, *Johnst.*	....	....	weedy.	20–30	North. & Celt.
chiagii, *Forb.*........	....	....	mud.	7–180	
Ophiothrix, Mul. & Tros.	1	1?			
rosula, *Forb.*........	....	....	weedy.	20–30	North. & Celt. [Can.
ASTERIADÆ.					
Uraster, Ag.	1	3			
glacialis, *Lin.*	....	....	rock.	$\frac{1}{2}$	North. & Celt.
Ophidiaster, Ag.	1				
lævigata, *Lam.*	....	....	rock.	lit.	
Cribrella, Ag.	1				
seposita, *Lam.*	....	....	weedy.	20–30	
Goniaster, Agass.	1	1			
sp.	....	....	nullipore.	60	
Asterina, Nardo	3	3			
sp.	....	....	rock.	lit.	
sp.	....	....	nullipore.	20–70	
sp.	....	....	sand & zost.	10–20	
Luidia, Forb..........	1	1			
sp.	....	....	mud.	20	
Asterias, Lin..........	3	4			
sp.	....	....	sand.	$\frac{1}{2}$–8	
sp.	....	....	sand.	$\frac{1}{2}$–8	
sp.	....	....	mud.	5	
sp.	....	....	mud.	3	
Palmipes, Link	1	1			
membranaceus, *Retz* ..	....	....	....	30	North. & Celt.
ECHINIDÆ.					
Cidaris, Leske	1	1			
histrix, *Lam.*........	....	....	nullipore.	55–105	
Echinus, Lin.	3	7			
esculentus, *Lin.*......	....	....	weedy.	7–40	Bay of Biscay, [Ireland.
lividus, *Lam.*........	....	....	rock.	lit.	
monilis, *Def.*	....	....	nullipore.	15–105	
Echinocyamus, Leske ..	1	1			Celt. & North [seas.
pusillus, *Mul.*	....	....	nullipore.	8–200	
Spatangus, Klein	2	3?			Atlantic.
purpureus, *Mul.*......	....	....	weedy.	20	
Amphidetus, Ag.	1	2?			
mediterraneus, *Forb.*..	....	....	sand.	20–30	
Brissus, Klein	2	2 or 3			
atropos?, *Lam.*......	....	....	weedy.	20–30	
sp. und.............	....	....	mud, nul.	60–130	

Species.	Ægean.	Medit.	Ground.	Depth.	Geog. Distrib.
HOLOTHURIADÆ.				fathoms.	
Holothuria, Lin.	4	6?			
tremula, *Lin.*	....	....	sand.	1	
sp.	....	....	weed.	3	
sp.	....	....	rock.	½	
sp.	....	....	rock, weed.	½	
Cucumaria, Blainv.	1	?			
pentactes, *Mul.*	....	....	mud.	11	Celt. & North [seas.
Ocnus, Forb.	1	?			
sp.	....	....	rocky.	½	
Chirodota, Eschs.	1	4?			
sp.	....	....	mud.	6–11	
SIPUNCULIDÆ.					
Syrinx, Bohadsch.		?			
nudus, *Lin.*	1	2	sand.	lit. ½.	Celtic, Lus.
sp.	....	....	rocky.	lit.	
Sipunculus, *Lin.*	3	?			
sp.	....	....	weedy.	0–8	
sp.	....	....	weeds.	2–3	
sp.	....	....	rock.	lit.	
Bonellia.	1	1?			
sp.	....	....	rock.	lit.	

Zoophyta.

Zoophytes are, on the whole, scarce in the Ægean. They seem to suffer the same diminishing influence as to size with the Mollusca, very numerous minute specimens occurring of *Corallium rubrum*, for instance, but none being met with of sufficient size as to render them of value in commerce. Corallines are scarce, a very few species only being common, among others *Farcimia fistulosa*. *Flustræ* are very rare; incrusting corallines frequent. The only corals met with of any size were *Cladocora cæspitosa* and *Porites dædalea*. The former is extremely abundant near water-mark on the coast of Asia Minor, where it forms elegant cauliflower-like patches of bright orange, from the hue of the animals, adhering to the rocks. The latter is rare, and was dredged alive in about 12 fathoms in the Bay of Serpho.

Among the soft Zoophytes there are several beautiful and curious species inhabiting the Ægean. In all six species were met with, of which one, the *Edvardsia vestita*, was remarkable for living in a tube of its own construction, formed of gravel and shells; and another for living entirely on the surface of the ocean, where it was frequently met with swimming during the winter months.

Alcyonia were not uncommon, but no species of *Pennatula* was met with, nor of *Gorgonia**.

The range of Zoophytes is very great in the Ægean, extending nearly to the greatest depths explored. A beautiful little waxy green *Idmonea?* was characteristic of depths below 100 fathoms, extending to 180. *Caryophyllia* (*cyathus*) ranged from 5 to 90 fathoms. *Hornera* at 40. *Plumulariæ* ranged to 40. *Myriapora truncata* was found as deep as 70 fathoms alive. *Tubu-*

* Two species of *Pennatula* have since been procured in abundance off the mouth of the Hermus in 7 fathoms, by Lieut. Spratt.

lipora serpens in 20 to 40 fathoms. *Retepora* abundant between 15 and 30. *Alecto* incrusting shells in 150 fathoms. Four species of coral were taken, though dead, at 105 fathoms. *Eudendrium* was found at 20 fathoms. *Valkeria* and *Campanularia* at 30. *Crisia* at 20. *Actinia* ranged from the surface to 20 fathoms. *Alcyonium* as deep as 70.

Amorphozoa.

Sponges abound in the Ægean, inhabiting all depths of water between sea-mark, where the rocks are often of a brilliant scarlet with incrusting species, to nearly 200 fathoms, a sponge allied to *Grantia* having been dredged alive at 180 fathoms, and a small species of another genus at 185. The sponge of commerce is procured by divers from rocks in various depths between 7 and 30 fathoms. Most of the larger species are found at lesser depths, very large ones occurring in the second zone or region. The forms of the species do not appear to bear any relation to the depth in which they are found, tubular sponges, globular, incrusting and palmate species all inhabiting the littoral zone. I met with about twenty species of *Amorphozoa* in the eastern Mediterranean.

The distribution of marine animals is determined by three great primary influences, and modified by several secondary or local ones. The primary influences are climate, sea-composition and depth, corresponding to the three great primary influences which determine the distribution of land animals, namely climate, mineral structure and elevation. The first of these primary marine influences is uniform in the eastern Mediterranean. From Candia to Lycia, from Thessaly to Egypt, we find the same species of Mollusca and Radiata assembled together under similar circumstances. The uniformity of distribution throughout the Mediterranean is very surprising to a British naturalist, accustomed as we are to find distinct species of the same genera, *climatally representative* of each other, in the Irish and North seas, and on the shores of Devon and Zetland. The absence of certain species in the Ægean which are characteristic of the western Mediterranean, is rather to be attributed to sea-composition than to climate. The pouring in of the waters of the Black Sea must influence the fauna of the Ægean and modify the constitution of its waters. To such cause we must attribute the remarkable fact, that with few exceptions individuals of the same species are dwarfish compared with their analogues in the western Mediterranean. This is seen most remarkably in some of the more abundant species, such as *Pecten opercularis, Venerupis irus, Venus fasciata, Cardita trapezia, Modiola barbata*, and the various kinds of *Bulla, Rissoa, Fusus*, and *Pleurotoma*, all of which seemed as if they were but miniature representatives of their more western brethren.

To the same cause may probably be attributed the paucity of *Medusæ* and of corals and corallines. Sponges only seem to gain by it. The influence of depth is very evident in the general character of the Ægean fauna, in which the aborigines of the deeper recesses of the sea play an important part numerically, both as to amount of species and individuals.

The secondary influences which modify the distribution of animals in the Ægean are many. First in importance ranks the character of the sea-bottom, which, though uniform in the lowest explored region, is very variable in all the others. According as rock, sand, mud, weedy or gravelly ground prevails, so will the numbers of the several genera and species vary. The presence of the sponges of commerce often depends on the rising up of peaks of rock in the deep water near the coast. As mud forms by much the most extensive portion of the bottom of the sea, bivalve Mollusca abound more individually though not specifically than univalves. As the deepest sea-bottom is of fine mud, the delicate shells of Pteropoda and Nucleobranchiata are for the most part only preserved there. Where the bottom is weedy we find the naked Mollusca more numerous than elsewhere; where rocky, the strong-shelled Gasteropoda and active Cephalopoda. Few species either of Mollusca or Radiata inhabit all bottoms indifferently.

The nature of the sea-bottom is mainly determined by the geological structure of the neighbouring land. The general character of the fauna of the Ægean is in a great measure dependent on the great tracts of scaglia which border it, and of which so many of its islands are formed. The degradation of this cretaceous limestone fills the sea with a white chalky sediment, especially favourable to the development of Mollusca. Where the coast is formed of scaglia numerous marine animals abound which are scarce on other rocks. The genera *Lithodomus* and *Clavagella* among Mollusca, the *Cladocora cæspitosa* among Zoophytes, are abundant in such localities only.

In a report on the distribution of British terrestrial and fluviatile Mollusca, which I had the honour of presenting to the Association at Birmingham, I asserted that a remarkable negative influence was exercised by serpentine on the distribution of pulmoniferous Mollusca. This I have had peculiarly favourable opportunities of confirming in the Ægean, where whole islands being formed of serpentine, the almost total absence of those animals which are abundant on the islands of other mineral structure is most striking. But I found further, that not only does serpentine exercise a negative influence on air-breathing Mollusca, but also on marine species. An extensive tract on the coast of Lycia and Caria, indented with deep and land-locked bays, is formed of that rock. In such bays, with the exception of a few littoral species which live on all rocks, we find an almost total absence of Testacea; whilst in correspondent bays in the neighbouring districts, formed of scaglia, of saccharine marble, and even of slate, we find an abundance of Testacea, so that it can hardly be doubted that the absence or scarcity of shelled Mollusca in such case is owing to negative influence exercised by the serpentine. *The outline of the coast* is evidently an important element in such influences, or in modifying it.

Tides and *currents* in most seas are important modifying influences. In the Ægean the former are so slight as scarcely to affect the fauna; the latter, in places, must be powerful agents in the transportation of species and of the spawn of marine animals. Their action, however, like that of storms, appears materially to affect the upper regions only; the transportation of the species of one region into another seldom extending further than that of the regions immediately bounding that in which it is indigenous. Certain species, such as the *Rissoæ*, which live on sea-weed, may occasionally fall to the bottom region, of which they are not true natives, and may live for a time there, but such cases appear to be rare, and the sources of fallacy from *natural transportation* are fewer than might be imagined at first thought, and in most cases have arisen rather from the form of the coast than from currents. Thus where the coast-line is very steep, the sea suddenly deepening to 60 or 70 fathoms close to the rocks, limpets, littoral *Trochi* and other shells, when they die, fall to the bottom, and are found along with the exuviæ of the natural inhabitants of those depths. Several instances of this occurred during dredging.

The *influx of fresh water*, whether continual, or where a river empties itself into the sea, or temporary, as on the coast of Asia Minor during the rainy season, when every little ravine becomes suddenly filled with a raging torrent, bearing down trees and great masses of rock, and charged with thick mud, frequently modifies the marine fauna of certain districts very considerably. The first generates great muddy tracts, which present a fauna peculiar to themselves: the second, though of short duration, deposits detached patches of conglomerate, and by the sudden settling of the fluviatile mud forms thin strata at the bottom of the sea, often containing the remains of terrestrial and fluviatile animals, soon to be covered over by marine deposits with very different contents. From the influx of a great river we may have tropical or subtropical, terrestrial or fluviatile forms mingled with temperate marine. Thus among forty-six species of Testacea collected by Captain Graves and Mr. Hoskyn on the shore at Alexandria, there are four Egyptian land and freshwater Mollusca, three of which are of truly subtropical forms, viz. *Ampullaria ovata, Paludina unicolor*, and *Cyrena orientalis*. The marine associates of these are, however, noways more southern in appearance, and for the most part identical as species with the Testacea which strew the shore at Smyrna or at Toulon, in the former case mingled with Melanopsis, in the latter with characteristic European Pulmonifera.

When the sea washes the shores of Egypt, remains of vegetables of a subtropical character become mingled with similar associations of marine Mollusca with those in which the relics of more northern plants become imbedded in the waters of the Black Sea. The Nile may carry down the woods and animals of Upper Egypt, the Danube those of the Austrian Alps. Deposits presenting throughout similar organic contents of marine origin, may contain at one point the relics of marmots and mountain salamanders, at another those of ichneumons and crocodiles.

Vegetable remains are being imbedded in strata forming at very different depths. Thus olive leaves were scattered among the mud dredged from a depth of 30 fathoms on the coast of Lycia, at Symboli, and date stones and monocotyledonous wood from a depth of nine fathoms off Alexandria. Of course the associated Mollusca were very distinct in each instance, in the first being members of the fourth, in the second of the second region of depth.

Provinces of Depth.

There are eight well-marked regions of depth in the eastern Mediterranean, each characterised by its peculiar fauna, and when there are plants, by its flora. These regions are distinguished from each other by the associations of the species they severally include. Certain species in each are found in no other, several are found in one region which do not range into the next above, whilst they extend to that below, or *vice versâ*. Certain species have their maximum of development in each zone, being most prolific in individuals in that zone in which is their maximum, and of which they may be regarded as especially characteristic. Mingled with the true natives of every zone are stragglers, owing their presence to the action of the secondary influences which modify distribution. Every zone has also a more or less general mineral character, the sea-bottom not being equally variable in each, and becoming more and more uniform as we descend. The deeper zones are greatest in extent; so that whilst the first or most superficial is but 12, the eighth, or lowest, is above 700 feet in perpendicular range. Each zone is capable of subdivision in smaller belts, but these are distinguished for the most part by negative characters derived from the cessation of species, the range of which is completed, and from local changes in the nature of the sea-bottom.

First Region, or Littoral Zone.

The first of the provinces in depth is the least extensive, and two fathoms may be regarded as its inferior limit. Its mineral nature is as various as the coast-line, and its living productions are influenced accordingly; sand, rock or mud presenting their several associations of species. Limited, too, as is its extent, it nevertheless presents well-marked subdivisions. That portion which forms the water-mark, and which (though in the Mediterranean the space be very small in consequence of the very slight tides) is left exposed to the air during the ebb, presents species peculiar to itself. Such on rock are *Littorina cœrulescens*, *Patella scutellaris*, *Kellia rubra*, *Mytilus minimus*, and *Fossarus adansoni*; on sand, *Mesodesma donacilla*, a bivalve which buries itself in great numbers immediately at the water's edge; in mud, a mineral character almost always derived from the influence of the influx of fresh water, *Nassa mutabile* and *neritoidea*; *Cerithium mammillatum* on all bottoms, usually under stones or weed; *Truncatella truncata* and *Auricula*. All these species are gregarious, most of them occurring in considerable numbers, and they are almost all Mollusca having a great geographic range; eight out of the eleven being widely distributed in the Atlantic, and one, the *Littorina cœrulescens*, extending from Tristan d'Acuna to the shores of Norway. The fuci of the coast-line, such as *Dictyota dichotoma* and *Corallina officinalis*, are also species of wide geographic diffusion. The bottomless barnacles (*Ochthosia*) are characteristic of this belt.

Immediately below this boundary line between the air and the water, we have a host of Mollusca of peculiar forms and often varied colours, associated with numerous Radiata and Articulata. In this under-belt we find the most characteristic Mediterranean forms, those which exhibit the action of the climatal influence most evidently. Boring in the sand live *Solen strigillatus*, *Lucina desmarestii*, *Amphidesma sicula*, *Venerupis decussata*, and various species of *Donax*, *Tellina* and *Venus*; in the mud abounds *Lucina lactea*; on the rocks we find *Cardita calyculata*, *Arca barbata*, *Chama gryphoides*, *Lithodomus*, *Chiton squamosus* and *cajetanus*, *Patella bonnardi*, *Fissurella costaria*, several species of *Vermetus*, *Haliotis*, numerous and peculiar *Trochi*, *Cerithium fuscatum*, *Fasciolaria tarentina*, *Fusus lignarius*, *Murex trunculus*, *Pollia maculosa*, *Columbella rustica*, *Cypræa spurca*, and *Conus mediterraneus*, with various Radiata and Articulata, most of them peculiar forms. In this belt, in fact, we have the characteristic species of the Mediterranean fauna, those animals which give a subtropical aspect to the general assemblage of forms in that sea. It is worthy of note, that not only is the climatal influence evident in the colouring and size of the shells of Mollusca in this region, but also in that of the animals themselves, which often present the most varied combinations of brilliant hues, sources of well-marked specific character. This is especially the case with the Gasteropoda, and is equally true with the sublittoral forms of the Northern as of the Southern seas.

It is only in this subdivision of the highest zone that we see distinct instances of local distribution of species in the Ægean. This is especially the case with the genus *Trochus*, some of the species of which have a very limited distribution, though always abundant where they occur. It is also the case with the naked Mollusca and with Zoophytes. Among the last, the rocks of the first zone in Asia Minor are well distinguished from those in the islands, by the great abundance of a beautiful coral, *Cladocora cæspitosa*, which is found in large masses, but does not appear to live deeper than six or eight feet below the surface of the water. In the sheltered gulfs of Lycia and Caria, sponges (not the kinds used in commerce) of singular shapes and bright colours abound in this region, growing to a considerable size. In the Cyclades the beautiful *Actinea rubra* abounds in similar localities. *Padina* *pavonia* is the characteristic *Fucus* of the belt of the first region, and among its elegant fronds may be seen innumerable Crustacea prowling, whilst in the crevices of the rocks on which they grow live numerous fishes of the blenny and wrasse tribes, like all the other natives of this province, remarkable for the vivid painting of their skins.

The inhabitants of the lowest portion of this narrow but varied belt are equally characteristic, especially such as live on the sandy tracts covered with *Zostera*. The *Pinna squamosa* is most abundant here, and in rocky places the cuttle-fishes abound. On the Zostera live numerous *Rissoæ*.

Besides its true inhabitants, the littoral zone is continually receiving accessions to its fauna from the washing up of the exuviæ of the animals of the succeeding region, especially after storms, which strew the sandy shores with the remains of Mollusca. Mingled with these are the remains of freshwater animals carried into the sea by the streams. These are not necessarily found in the immediate neighbourhood of the streams by which they are brought down, but seem to be carried along the shore by eddies and currents, so that in a deep bay they may frequently be found at the opposite part of the shore to that where the stream which doubtless wafted them to the sea emptied itself, the depth of the intermediate gulf precluding the notion that they could have been washed across. Whilst the sea one day casts up numerous shells, Crustacea, &c., it often covers them up with silt the next, so that increasing alternations of organic bodies and sand or mud must be continually in process of formation in this region.

Testacea of Region I.

Lamellibranchiata.

Clavagella ——*
Solen siliqua.
Solecurtus strigillatus.*
Ligula sicula.
Mactra stultorum.*
Kellia corbuloides.*
    rubra.*
Tellina donacina.
    fragilis.
    planata.
Lucina pecten.
    digitalis. ?
    lactea.*
    desmarestii.*
Venerupis irus.*
    decussata.*
Donax trunculus.*
    complanata.
    semistriata.
Mesodesma donacilla.*
Venus gallina.*
    decussata.*
    geographica. ?
Cardium rusticum.
    edule.*
Cardita calyculata.*
    trapezia.*
Arca barbata.*
    lactea.*
    noæ.*
Lithodomus lithophagus.*
Mytilus gallo-provincialis.*
    minimus.*
Pinna squamosa.*
Lima squamosa.*
    tenera. ?
Spondylus gadæropus.*
Ostrea plicatula.*

Gasteropoda.

Chiton squamosus.*
    cajetanus.*
    fascicularis.*
Patella scutellaris.*
    ferruginea.*
    bonnardi.*

Note.—The asterisk indicates that the species attains its maximum of development in that region; the note of interrogation implies that the species is probably a straggler.

Patella lusitanica.*
Gadinia garnoti. ?
Crepidula fornicata.
unguiformis.*
Emarginula huzardi.*
Fissurella costaria.*
gibba.*
Bullæa angustata. ?
aperta. ?
Bulla striata.
cornea. ?
truncatula. ?
truncata. ?
striatula. ?
Eulima polita. ?
Parthenia elegantissima. ?
humboldti.
Truncatella truncatulum.*
Rissoa desmarestii.*
ventricosa.*
oblonga.*
violacea.*
monodonta.*
fulva.
cancellata.
granulata.
montagui.*
acuta.
pulchella.
conifera.
cingilus.
pulchra.
Littorina cœrulescens.*
Fossarus adansoni.*
Scalaria lamellosa. ?
Vermetus gigas.*
subcancellatus.*
arenarius.*
glomeratus.*
granulatus.*
Nerita viridis. ?
Haliotis lamellosus.*
Adeorbis subcarinata.
Trochus vielloti.*
jussieui.*
pallidus.*
umbilicaris.*
lyciacus.*
richardi.*
divaricatus.*
articulatus.*
Trochus fragarioides.*
therensis.*
laugieri. ?
Phasianella pulla. ?
Ianthina nitens,* strag.
Cerithium fuscatum.*
mammillatum.*
lima. ?
trilineatum. ?
Triforis adversum. ?
Pleurotoma albida. ?
rude. ?
purpurea. ?
lævigata. ?
lefroyi. ?
fallax. ?
linearis. ?
lyciaca. ?
Fasciolaria tarentina.*
Fusus lyciacus. ?
lavatus. ?
Murex brandaris. ?
trunculus.*
edwardsii.*
Ranella lanceolata. ?
Purpura hæmastoma.
Pollia maculosa.*
candidissima. ?
Nassa reticulata.
d'orbignii. ?
variabile. ?
cornicula.*
mutabile.*
gibbosula.*
neritea.*
Columbella rustica.*
linnæi.*
Mitra littoralis. ?
cornea. ?
Marginella miliacea. ?
Ringuicula buccinea. ?
Cypræa lurida.
rufa.*
spurca.*
Conus mediterraneus.*
Dentalium 9-costatum. ?
multistriatum. ?
entalis. ?
rubescens. ?
Auricula myosotis.*

Second Region.

The ground in the second region, which extends from two to ten fathoms, is most generally mud or sand, the former green with a beautiful Fucus, *Caulerpa prolifera*, abundant in the Archipelago, but I believe rare elsewhere, the latter abounding in *Zostera oceanica*. Great *Holothuriæ* are here found in abundance, and, among Mollusca, chiefly burying Conchifera. *Nucula margaritacea* and *Cerithium vulgatum* are the Testacea most generally distributed through this region. Those most prolific in individuals are, among Gasteropoda, *Cerithium vulgatum* and *lima*, *Trochus crenulatus* and *spratti*, *Rissoa ventricosa* and *oblonga*, and *Marginella clandestina*. Among Lamellibranchiata, *Tellina donacina*, *Lucina lactea*, *Nucula margaritacea*, and *Cardium exiguum*. Storms disturb this zone by washing up its inhabitants into the littoral region.

The smaller zoophytes, especially encrusting species and such as attach themselves to the leaves of *Zostera*, are frequent. *Caryophyllia cyathus* begins to appear here, ranging however through all the succeeding zones.

Testaceous Mollusca inhabiting the Second Region.

Lamellibranchiata.

Solen tenuis.*
antiquatus.
Solecurtus strigillatus.
Ligula boysii.*
Solenomya mediterranea.*
Montacuta sp.
Byssomya guerinii.
Corbula nucleus.*
Pandora obtusa.
rostrata.
Thracia phaseolina.
Psammobia vespertina.
Donax venusta.
Cytherea chione.
lunata.
apicalis.
Venus gallina.*
verrucosa.*
aurea.*
geographica.*
Tellina donacina.*
serrata.
balaustina.
distorta.*
Lucina flexuosa.
pecten.
lactea.*
Lucina rotundata.
spinifera.
transversa.
Cardium papillosum.*
rusticum.
exiguum.
Cardita sulcata.
trapezia.
Arca barbata.
lactea.*
Pectunculus glycimeris.*
Nucula emarginata.*
nuclea.
Modiola barbata.*
tulipa.*
discrepans.*
marmorata.*
Pinna squamosa.
Lima squamosa.
tenera.
Pecten polymorphus.*
hyalinus.*
varius.
sulcatus.
Spondylus gadæropus.
Ostrea plicatula.*
Chama gryphoides.

Palliobranchiata.

0.

Gasteropoda.

Chiton rissoi.*
polii.*
Calyptræa sinense.*
Crepidula unguiformis.*

Emarginula huzardii.
Bulla hydatis.*
cornea.
ovulata.
striatula.
truncatula.*
turgidula.
Natica valenciensii.*
pulchella.
olla.*
Eulima polita.*
subulata.
Parthenia elegantissima.
Odostomia conoidea.
Rissoa desmarestii.*
ventricosa.*
oblonga.*
violacea.*
radiata.*
cimicoides.*
montagui.*
buccinoides.*
pulchella.*
acuta.
Scalaria communis.
Turritella triplicata.
terebra.*
Nerita viridis.*
Dentalium 9-costatum.*
multistriatum.*
entalis.*
fissura.*
Trochus canaliculatus.*
racketti.*
spratti.*
fanulum.*
Trochus adansoni.*
conulus.*
crenulatus.*
gravesi.*
exiguus.*
Turbo rugosus.*
Phasianella pulla.*
intermedia.*
vieuxii.*
Cerithium lima.*
angustissimum.
Triforis adversum.*
Pleurotoma formicaria.*
reticulata spinosa.*
attenuata.*
linearis.*
Fusus syracusanus.*
lavatus.*
lignarius.
Murex brandaris.*
trunculus.*
edwardsii.*
fistulosus.*
Ranella gigantea.*
Nassa reticulata.*
variabile.*
musiva.
granulata.*
macula.*
mutabile.*
Columbella rustica.*
linnæi.*
Mitra obsoleta.*
Marginella clandestina.*
Ringuicula buccinea.*
Conus mediterraneus.*

Third Region.

In this region, which extends from ten to twenty fathoms, the sea-bottom is very generally gravelly in places, great tracts of sand also being common. The *Caulerpa* and *Zostera* are still found, but cease towards its lower part. It may be regarded as a zone of transition presenting but few peculiarities. A very small and beautiful species of *Asterina* abounds on the fronds of *Zostera* here, and the large *Holothuriæ* are still abundant. *Aplysiæ* and the blue *Goniodoris* are the characteristic Mollusca. *Lucina lactea*, *Cardium papillosum*, *Tellina donacina*, and *Cerithium lima* are the Testacea most generally distributed. The species most prolific are *Cerithium lima*, *Cardium papillosum*, *Ligula boysii*, *Nucula margaritacea* and *emarginata*, *Lucina lactea* and *hiatelloides*, so that bivalves would appear to prevail.

Testacea of Region III.

Lamellibranchiata.

Solen tenuis. ?
Solen antiquatus.*

Ligula boysii.*
Corbula nucleus.*
Neæra cuspidata.*
Pandora obtusa.
Thracia phaseolina.
Psammobia vespertina.?
Tellina pulchella.*
donacina.*
serrata. ?
balaustina.
Lucina flexuosa.*
pecten.
commutata.
transversa.*
lactea.*
spinifera.*
Cytherea chione.
lunata,
apicalis.
Venus verrucosa.
geographica.
virginea.*
Cardium echinatum.
papillosum.*
exiguum.*
Cardium punctatum.*
Cardita sulcata.
trapezia.*
Arca lactea.
Pectunculus glycimeris. ?
Nucula margaritacea.
emarginata.
Chama gryphoides.
Modiola barbata.
tulipa.
discrepans.*
marmorata.*
Pinna squamosa.
Lima squamosa. ?
tenera. ?
subauriculata.
Pecten jacobæus.
polymorphus.
hyalinus.
opercularis.
varius.
pusio.
Spondylus gadæropus.
Ostrea plicatula.

Gasteropoda.

Calyptræa sinense.
Fissurella græca.
Bulla convoluta.
ovulata.
striatula.
truncatula.
truncata.
akera.
Natica millepunctata.
pulchella.
guilleminii.
valenciensii.
Eulima polita.
subulata.
Parthenia elegantissima.
Odostomia conoidea. ?
Rissoa ventricosa.*
violacea.*
cimicoides.*
montagui.
acuta. ?
conifera. ?
pulchella.
Scalaria communis.
Turritella triplicata.
terebra*.
Nerita viridis.
Trochus coutourii.
canaliculatus.*
racketti.*
villicus.*
spratti.*
fanulum.
adansoni.
ziziphinus.*
conulus.*
crenulatus.*
gravesi.*
exiguus.
Turbo rugosus.
Phasianella pulla.
vieuxii.*
Cerithium vulgatum.*
lima.*
angustum.*
Triforis adversum.*
Pleurotoma formicaria.
bertrandi.
reticulata spinosa.*
gracilis.
attenuata.
ægeensis.*
linearis.?
Fusus lignarius.

Fusus syracusanus.
 lavatus.*
Murex brandaris.*
 trunculus. ?
 fistulosus. ?
Aporrhais pes-pelecani.*
Dolium galea. ?
Nassa prismatica.
 variabile.*
 granulata. ?
Nassa cornicula ?
Columbella rustica.*
 linnæi.*
Mitra savignii.*
 obsoleta.
Marginella clandestina.
Erato lævis.
Conus mediterraneus.?
Dentalium 9-costatum.*
 multistriatum.

Fourth Region.

It extends through fifteen fathoms of length between twenty and thirty-five fathoms. The sea-bottom is very various, mud and gravel prevailing, sandy tracts being very rare. *Fuci* are abundant, the characteristic species being *Dictyomenia volubilis, Sargassum salicifolium, Codium bursa* and *flabelliforme,* and *Cystoceira.* The rare and curious *Hydrodictyon umbilicatum* was procured in this region on the coast of Asia Minor. Corallines are more frequent here than in the other zones. *Porites dædalea* occurs, but is very local. *Retepora cellulosa* is very abundant; several species of *Tubulipora* occur; *Myriapora truncata* and *Cellaria ceramioides* are characteristic species of this zone. Sponges abound, and some of the finest of those used in commerce grow here. Nullipore is abundant. *Echinidæ* are frequent, and *Comatula.* Crustacea are common, also *Annelides.*

Among Testacea the most generally distributed are *Nucula margaritacea* and *emarginata,* and *Dentalium 9-costatum*: those most prolific are *Nucula margaritacea, Arca lactea, Cardium papillosum, Corbula nucleus,* and *Ligula boysii*; *Dentalium 9-costatum* and *Cerithium lacteum. Mollusca tunicata* are common in this region.

Testacea of Region IV.

Lamellibranchiata.

Gastrochæna cuneiformis.
Solen tenuis.?
 antiquatus.*
Ligula boysii.*
 prismatica.
Kellia suborbicularis.*
Corbula nucleus.*
Neæra costellata.*
 cuspidata.*
Pandora obtusa.*
Lyonsia striata.*
Thracia phaseolina.
Saxicava arctica.*
Psammobia discors.
 ferroensis.
Tellina donacina.
 serrata.
 balaustina.
Lucina commutata.
 digitalis.
Lucina transversa.
 lactea.?
 spinifera.
Astarte incrassata.
Cytherea apicalis.*
 venetiana.
Venus verrucosa.
 ovata.*
 fasciata.
Cardium echinatum.
 erinaceum.
 lævigatum.
 papillosum.*
 exiguum.*
Cardita sulcata.*
 squamosa.
 trapezia.
Arca lactea.*
 tetragona.*
 noæ. ?

Pectunculus glycimeris.
pilosus.
lineatus.
Nucula margaritacea.*
emarginata.*
Chama gryphoides.
Modiola barbata.*
tulipa.*
discrepans.*
marmorata.*
Pinna squamosa.
Avicula tarentina.
Lima squamosa.*
tenera.
Lima fragilis.*
subauriculata.
Pecten jacobæus.*
polymorphus.*
hyalinus.*
testæ.*
opercularis.*
varius.*
pusio.*
similis.
Ostrea plicatula.
Anomia ephippium.*
polymorpha.*

Palliobranchiata.

Terebratula detruncata.
Terebratula cuneata.*

Gasteropoda.

Chiton lævis.*
freelandi.*
Calyptræa sinehse.
Emarginula elongata.
Fissurella græca.*
Bullæa aperta.*
Bulla hydatis.
cornea.*
ovulata.*
striatula.
truncatula.
truncata.
convoluta.
Natica millepunctata.
valenciensii.
pulchella.
Eulima polita.
nitida.
subulata.*
Parthenia acicula.
elegantissima.*
scalaris.
varicosa.
Odostomia conoidea.*
Rissoa ventricosa.*
cimicoides.
montagui.
reticulata.
acuta. ?
pulchella.*
striata.
elongata. (?)
Turritella triplicata.*
terebra.
Vermetus corneus.
Nerita viridis. ?
Trochus coutourii.
magus.*
spratti.*
fanulum.
adansoni.
ziziphinus.*
conulus.*
gravesi.
exiguus.*
Turbo sanguineus.*
rugosus.*
Phasianella pulla.
vieuxii.*
Cerithium vulgatum.*
lima.*
lacteum.
angustissimum.
Triforis adversum.*
Pleurotoma formicaria.*
reticulata var. spinosa.*
maravignæ.*
vauquelini.*
gracilis.
attenuata.*
philberti.*
turgida.*
linearis.
Fusus lignarius. ?
syracusanus.*
lavatus.
Murex brandaris.*
trunculus. ?

Murex cristatus.
brevis.*
fistulosus.
Aporrhais pes-pelecani.*
Nassa variabile.
varicosa.
granulata.
prismatica.
Columbella rustica.*
linnæi.
gervillii.
Mitra ebenus.*
Mitra savignii.*
obsoleta.*
granum.*
Marginella clandestina.*
secalina.*
miliacea.
Erato lævis.
Tornatella fasciata.
Cypræa europæa.
Conus mediterraneus.?
Dentalium 9-costatum.*
rubescens.*

Fifth Region.

From thirty-five to fifty-five fathoms, an extent of five fathoms more than the last, presents a well-marked fauna, and constitutes a fifth region. *Fuci* are much scarcer than in the last, but among its vegetable products are *Rytiphlœa tinctoria, Chrysimenia uvaria,* and *Dictyomenia volubilis*; the last, which gives a marked character to the preceding zone, being rare in this. Echinodermata are frequent here, Zoophytes not abundant. *Myriapora truncata* is frequent. The bottom is very generally nullipore and shelly. Muddy bottoms are scarce. The Testacea most generally distributed are *Nucula margaritacea, Pecten opercularis,* and *Turritella tricostata.* Those most abounding in individuals are *Nucula emarginata* and *striata, Cardium papillosum, Cardita aculeata,* and *Dentalium 9-costatum.*

Testacea of Region V.

Lamellibranchiata.

Solen tenuis.*
antiquatus.*
Ligula boysii.
prismatica.
Kellia suborbicularis.*
Corbula nucleus.*
anatinoides.
Neæra cuspidata.*
costellata.*
Pandora obtusa.
Lyonsia striata.?
Saxicava arctica. *
Psammobia discors.
ferroensis.
Tellina donacina.
serrata.
balaustina.*
Lucina commutata.
spinifera.*
Astarte incrassata.
Cytherea venetiana.
apicalis.*
Venus verrucosa.
ovata.
fasciata.
Cardium echinatum.
lævigatum.
papillosum.
Cardita squamosa.
trapezia.
Arca lactea.*
imbricata.
antiquata.
tetragona.*
Pectunculus pilosus.
Nucula polii.
margaritacea.*
emarginata.*
striata.*
Chama gryphoides.?
Modiola barbata.*
tulipa.*
discrepans.
marmorata.
Lima squamosa.
fragilis.*
subauriculata.
cuneata.
Pecten jacobæus.
polymorphus.*

Pecten hyalinus.*
testæ.*
opercularis.*
varius.*
Pecten pusio.*
lævis.*
fenestratus.
Anomia ephippium.

Palliobranchiata.

Terebratula detruncata.*
cuneata. ?
Terebratula seminula.
Crania ringens.*

Gasteropoda.

Chiton lævis*
freelandi.*
Lottia gussonii.
Calyptræa sinense.*
Emarginula capuliformis.*
elongata.
Fissurella græca.*
Volva acuminata.
Bullæa aperta. ?
Bulla cornea.*
utriculus.
lignaria.
ovulata.
truncatula.*
truncata.
Natica millepunctata. ?
valenciensii. ?
pulchella.*
Eulima distorta.
nitida.*
Parthenia acicula.*
elegantissima. ?
pallida.
Odostomia conoidea.
Rissoa ventricosa.*
cimicoides.
reticulata.
Scalaria planicosta.
Turritella triplicata.*
terebra. ?
Vermetus corneus.*
Siliquaria anguina.
Trochus coutourii.
magus.*
fanulum.
ziziphinus.*
gravesi.
exiguus.
millegranus.*
Turbo sanguineus.*
Turbo rugosus.*
Phasianella pulla. ?
Cerithium vulgatum.*
lima.*
angustum.*
Triforis adversum.*
Pleurotoma formicaria.*
purpurea.
reticulata.
maravignæ.*
vauquelini.
gracilis.*
attenuata.
teres.
philberti.
Fusus lavatus.
muricatus.
crispus.
fasciolaria.
Murex brandaris.
muricatus.
distinctus.
fistulosus.
Aporrhais pes-pelecani.*
Cassidaria tyrrhena.
Nassa intermedia.
Columbella rustica.
linnæi.
Mitra ebenus.*
obsoleta.
phillippiana.
granum.
Tornatella fasciata.
Marginella clandestina.*
secalina.
Erato lævis.*
Cypræa europæa.*
Conus mediterraneus.?
Dentalium 9-costatum.

Sixth Region.

It extends through a range of twenty-four fathoms, between fifty-five and seventy-nine fathoms. Nullipore is the prevailing ground. *Fuci* have become extremely rare. *Cidaris histrix* is the characteristic Echinoderm. Several starfishes are not uncommon. *Venus ovata*, *Cerithium lima*, and *Pleurotoma maravignæ* are the most generally diffused species. *Turbo sanguineus*, *Emarginula elongata*, *Nucula striata*, *Venus ovata*, *Pecten similis*, and the various species of Brachiopoda those most prolific in individuals.

It will be observed, that although *Fuci* have become extremely scarce, and in the next zone altogether disappear, there are still a considerable number of Phytophagous Testacea. These are mostly found on "coral" ground, that is, on a clean bottom abounding in nullipore. Now that the observations of M. Decaisne, M. Kutzing and others have so clearly proved the vegetable nature of that singular production, so long regarded as a zoophyte, the source of the food of the Holostomatous Testacea in these deep regions is no longer problematical.

Testacea of Region VI.

Lamellibranchiata.

Ligula profundissima.
Kellia suborbicularis.*
Corbula nucleus.*
  anatinoides.
Neæra cuspidata.
  costellata.*
  abbreviata.
Pandora obtusa.*
Lyonsia striata.*
Thracia pubescens.
Saxicava arctica.*
Kellia abyssicola.*
Lucina commutata.
  bipartita.*
Astarte incrassata.
  pusilla.
Cytherea apicalis.
Venus ovata.*
  fasciata.
Cardium papillosum.
  echinatum.
  minimum.
Cardita squamosa.*
  trapezia.
Arca lactea.*
  scabra.
  imbricata.
  tetragona.*
Pectunculus pilosus.*
Nucula polii.
  margaritacea.
  striata.*
Modiola barbata.
Lima squamosa.
  elongata.*
  crassa.
Pecten jacobæus.
  dumasii.
  polymorphus.
  hyalinus.
  testæ.
  varius.*
  pusio.
  pes felis.
  similis.*
  fenestratus.
  concentricus.
Anomia polymorpha.

Palliobranchiata.

Terebratula truncata.*
  detruncata.*
  cuneata.*
Terebratula seminula.*
Crania ringens.

Gasteropoda.

Chiton lævis.
Lottia gussonii.
Lottia unicolor.*
Calyptræa sinense.

Emarginula elongata.
  capuliformis.
Fissurella græca.
Bullæa aperta.?
Bulla cornea.*
  utriculus.?
Coriocella perspicua.
Natica millepunctata.
  valenciensii.
  pulchella.
Eulima distorta.
  subulata.
  unifasciata.
Parthenia elegantissima.?
Rissoa ventricosa.?
  cimicoides.
  reticulata.*
  ovatella.
Turritella 3-plicata.*
  terebra.*
Siliquaria anguina.
Scissurella plicata.
Solarium stramineum.
Trochus coutourii.
  fanulum.
  exiguus.*
  millegranus.*
Turbo sanguineus.
  rugosus.*
Phasianella pulla.
Cerithium lima.*
  angustum.
Triforis adversum.
  perversum.*
Pleurotoma formicaria.*
  crispata.*
  reticulata var. spinosa.
  maravignæ.*
  vauquelini.

Seventh Region.

The depths between 80 and 105 fathoms (an extent of 25), yield a characteristic fauna of their own. The sea-bottom is usually nullipore, more rarely sand or mud. Herbaceous *Fuci* have disappeared. *Echinodermata* are here not uncommon; *Zoophyta* and *Amorphozoa* scarce. Among the former are species of *Hornera, Lepralia* and *Cellepora*; among the latter a small round species of *Grantia* is frequent. *Echinus monilis, Cidaris histrix* and *Echinocyamus,* with some of the *Ophiuridæ,* are frequent alive: no *Asteriadæ* occur. *Mollusca tunicata* have ceased; as also *Nudibranchæa.* Crustacea are not unfrequent, as well as testaceous annelides, among which the glassy Serpula is very characteristic of this region.

The Testacea most generally distributed are *Lima elongata, Cardita aculeata, Rissoa reticulata,* and *Fusus muricatus.*

Those most prolific are *Rissoa reticulata, Turbo sanguineus, Venus ovata, Nucula striata, Pecten similis,* and the various species of Brachiopoda, which tribe abounds in this region.

Testacea of Region VII.

Lamellibranchiata.

Ligula profundissima.
Corbula nucleus.
Poromya anatinoides.
Neæra cuspidata.
  costellata.*
  abbreviata.
Pandora obtusa.
Saxicava arctica.*
Lucina commutata.
  bipartita.
Astarte incrassata.
  pusilla.
Cytherea apicalis.
Venus ovata.*
Cardium minimum.*
Cardita squamosa.*
Arca lactea.*
  scabra.
  imbricata.
  tetragona.
Nucula polii.
  margaritacea.
  striata.*
Modiola barbata.*
Lima elongata.
  crassa.

Pecten dumasii.
similis. ?
fenestratus. ?
concentricus. ?
Spondylus gussonii.*
Ostrea cochlear.
Anomia polymorpha.

Palliobranchiata.

Terebratula truncata.*
detruncata.*
lunifera.*
seminula.*
Terebratula vitrea.
appressa.*
Crania ringens.*

Gasteropoda.

Chiton lævis.*
Lottia unicolor.*
Pileopsis ungaricus.
Emarginula cancellata.
elongata.
capuliformis.
Fissurella græca.
Bullæa aperta. ?
Bulla utriculus.
Natica pulchella.
Eulima distorta.
subulata. ?
Parthenia elegantissima.
Rissoa ventricosa.*
reticulata.*
ovatella.
Turritella triplicata.
Scissurella plicata ?
Trochus tinei.
exiguus.*
millegranus.*
Turbo sanguineus.
rugosus.*
Phasianella pulla.*
Cerithium lima.*
Triforis adversum.
Pleurotoma formicaria. ?
crispata.*
reticulata.
maraviguæ.*
gracilis.*
Fusus muricatus.*
Murex cristatus.*
Nassa intermedia.
Mitra ebenus.*
phillippiana.
Tornatella fasciata.*
pusilla.
globulosa.
Marginella clandestina.
Dentalium 9-costatum.
5-angulare.

Eighth Region.

The eighth region includes all the space explored below 105 fathoms, extending from that depth to 1380 feet beneath the surface of the sea, having a range of 125 fathoms, being more than twice the extent of all the other regions put together. Throughout this great, and I may say hitherto unknown province, for the notices we have had of it have been but few and fragmentary, we find an uniform and well-characterized fauna, distinguished from those of all the preceding regions by the presence of species peculiar to itself. Within itself the number of species and of individuals diminishes as we descend, pointing to a zero in the distribution of animal life as yet unvisited. It can only be subdivided according to the disappearance of species which do not seem to be replaced by others.

Sixty-five species of Testacea were taken in the eighth region, eleven of which were procured alive. Of the total number 22 were Univalves, 3 of which were found living; 30 Lamellibranchiate Bivalves, 8 living; 3 Palliobranchiate Bivalves, all dead, and possibly derived from the preceding region; and 10 Pteropoda and Nucleobranchiata, also dead. Of these, 17 Univalves, 23 Lamellibranchiata, and 3 Palliobranchiata occurred above 140 and under 180 fathoms; 4 Univalves, 11 Lamellibranchiata, and 1 Palliobranchiate Bivalve above 180 and under 200; and 1 Univalve, 4 Lamellibranchiate, and 1 Palliobranchiate Bivalve above 200 fathoms.

The Mollusca found alive at the greatest depths were *Arca imbricata* in 230 fathoms; accompanied by *Dentalium quinquangulare.* At 180 fathoms living examples of *Nucula ægeensis, Ligula profundissima, Neæra attenuata* and *costellata, Arca lactea,* and *Kellia abyssicola* occurred. *Trochus millegranus* was taken alive in 110 fathoms, along with the *Dentalium pusillum* of authors, which proved to be an annelide of the genus *Ditrupa,* and of which three species live in this region.

Pecten hoskynsii, Lima crassa, Nucula ægeensis, Scalaria hellenica, Parthenia fasciata and *ventricosa,* all new species, have been found in no other region. *Ligula profundissima, Pecten similis, Arca imbricata, Dentalium quadrangulare* and *Rissoa reticulata,* are more prolific of individuals in this region than in any other. *Ligula profundissima* and *Dentalium quinquangulare* are the most generally diffused species below 105 fathoms; the former being present in eleven localities, the latter in seven. The localities examined were eleven in number and far apart from each other, extending from Cerigo to the coast of Lycia.

The *Bullæa angustata, Rissoa acuta, Cerithium lima* and *Teredo* are probably only stragglers in this region.

Several *Ophiuridæ* are true inhabitants of the eighth region; as *Ophiura abyssicola, Amphiura florifera, Amphiura chiagi* and *Pectinura vestita,* all well adapted by their organisation to live in the white mud of great depths. The only other Echinoderm was *Echinocyamus* at 200 fathoms, which however was not taken alive. The Zoophytes are *Caryophyllia cyathus, Alecto* and an *Idmonea,* which occurs in very deep water. Small sponges of three genera were taken alive as deep as 180 fathoms. The deepest living Crustacea occurred at 140 fathoms, and the carapaces of small species are frequent. Besides the *Ditrupæ,* annelides of the genus *Serpula* were taken in the greatest depths explored. *Foraminifera* are extremely abundant through a great part of the mud of this region, and for the most part appear to be species very distinct from those in the higher zones. Representatives of the genera *Nodosaria, Textularia, Rotalia, Operculina, Cristellaria, Biloculina, Quinqueloculina* and *Globigerina* are among the number.

Testacea of Region VIII.

Lamellibranchiata.

Teredo.
Ligula profundissima.
Corbula anatinoides.
Neæra cuspidata.*
costellata.*
attenuata.
Pandora obtusa.
Thracia pholadomyoides.
Kellia abyssicola.*
oblonga.
Astarte pusilla.
Venus ovata.
Lucina ferruginosa.
Cardium minimum.
Cardita squamosa.

Arca lactea.
scabra.
imbricata.
tetragona.
Nucula polii.
striata.*
ægeensis.*
Lima elongata.
crassa.
Pecten dumasii.
similis.
fenestratus.
hoskynsi.
Ostrea cochlea.?
Anomia polymorpha.

Palliobranchiata.

Terebratula detruncata.
vitrea.
Crania ringens.

Gasteropoda.

Lottia unicolor.
Bullæa aperta.
angustata.?
alata.
Bulla utriculus.
cretica.
Eulima subulata.
Parthenia ventricosa.
turris.
fasciata.
Rissoa reticulata.
ovatella.
Rissoa acuta.?
Scalaria hellenica.
Scissurella plicata.
Trochus millegranus.
Cerithium lima.?
Pleurotoma abyssicola.
Fusus echinatus.
Nassa intermedia, var.
Marginella clandestina.
Dentalium quinquangulare.
9-costatum?

The following Diagram exhibits the comparative characters and relations of the several regions:—

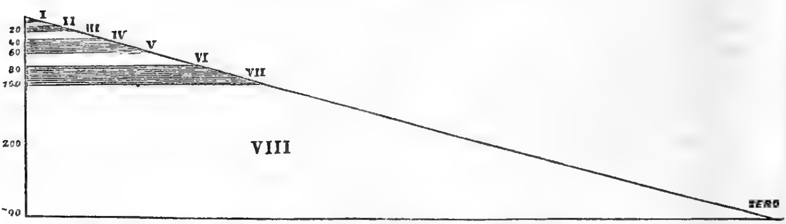
Diagram of Regions of Depth in the Ægean Sea.

Sea-Bottom = deposits forming.	Region.	Depth in fathoms.	Characteristic Animals and Plants.
Extent—12 feet. Ground various. Usually rocky or sandy (conglomerates forming).	I.	2	Littorina cœrulescens. Fasciolaria tarentina. Cardium edule. —— Plant:—Padina pavonia.
Extent—48 feet. Muddy. Sandy. Rocky.	II.	10	Cerithium vulgatum. Lucina lactea. Holothuriæ. —— Plants:—Caulerpa and Zostera.
Extent—60 feet. Ground mostly muddy or sandy. Mud bluish.	III.	20	Aplysiæ. Cardium papillosum.
Extent—90 feet. Ground mostly gravelly and weedy. Muddy in estuaries.	IV.	35	Ascidiæ. Nucula emarginata. —— Cellaria ceramioides. —— Plants:—Dictyomenia volubilis. Codium bursa.
Extent—120 feet. Ground nulliporous and shelly.	V.	55	Cardita aculeata. Nucula striata. Pecten opercularis. —— Myriapora truncata. —— Plant:—Rityphlœa tinctoria.
Extent—144 feet. Ground mostly nulliporous. Rarely gravelly.	VI.	79	Venus ovata. Turbo sanguineus. Pleurotoma maravignæ. —— Cidaris histrix. —— Plant:—Nullipora.

DIAGRAM OF REGIONS OF DEPTH IN THE ÆGEAN SEA (*continued*).

Sea-Bottom = deposits forming.	Region.	Depth in fathoms.	Characteristic Animals and Plants.
Extent—156 feet. Ground mostly nulliporous. Rarely yellow mud.	VII.	105	Brachiopoda. Rissoa reticulata. Pecten similis. —— Echinus monilis. —— Plant:—Nullipora.
Extent—750 feet. Uniform bottom of yellow mud, abounding for the most part in remains of Pteropoda and Foraminifera.	VIII.	230	Dentalium 5-angulare. Kellia abyssicola. Ligula profundissima. Pecten hoskynsi. —— Ophiura abyssicola. —— Idmonea. Alecto. Plants:—0.
Zero of Animal Life probably about 300 fathoms. —— Mud without organic remains.			

TRUE SCALE OF THE ABOVE DIAGRAM.



To all the eight regions only two species of Mollusca are common, viz. *Arca lactea* and *Cerithium lima*: the former a true native from first to last, the latter probably only a straggler in the lowest. Three species, namely, *Nucula margaritacea*, *Marginella clandestina* and *Dentalium 9-costatum*, are common to seven regions; the second possibly owing its presence in the lower ones to its having dropped off floating sea-weeds. Nine species are common to six regions.

Corbula nucleus.	*Turritella 3-plicata.*
Neæra cuspidata.	*Triforis adversum.*
Pandora obtusa.	*Columbella linnæi.*
Venus apicalis.	*Cardita trapezia.*

Modiola barbata.

Seventeen species are common to five regions.

Neæra costellata.	*Pecten hyalinus.*
Tellina pulchella.	*varius.*
Venus ovata.	*Crania ringens.*
Cardita squamosa.	*Natica pulchella.*
Arca tetragona.	*Rissoa ventricosa.*
Pecten polymorphus.	*cimicoides.*

Rissoa reticulata.
Trochus exiguus.
Columbella rustica.
Conus mediterraneus.
Terebratula detruncata.

When we inquire into the history of the species having such extensive ranges in depth, we find that more than one-half of them are such as have a wide geographic range, extending in almost every case to the British seas, and in some of those exhibiting the greatest range in depth, still further north; many of them also ranging in the Atlantic far south of the gut of Gibraltar. If, again, we inquire into the species of Mollusca which are common to four out of the eight Ægean regions in depth, we find that there are 38 such, 21 of which are either British or Biscayan, and 2 are doubtfully British, whilst of the remaining 15, 6 are distinctly represented by corresponding speoics in the north. Thus among the Testacea having the widest range in depth one third are Celtic or northern forms, whilst out of the remainder of Ægean Testacea, those ranging through less than four regions, only a little above a fifth are common to the British seas. One-half of the Celtic forms in the Ægean which are not common to four or more zones in depth, are found among the cosmopolitan Testacea, inhabiting the uppermost part of the littoral zone. From these facts we may fairly draw a general inference, that the *extent of the range of a species in depth is correspondent with its geographical distribution.*

The proportion of Celtic forms in the faunæ of the zones varies in the several great families of Testacea. In the accompanying tables I have exhibited this variation conchologically, in order that they may be more useful to the geologist than if the unpreservable species were included. It will be seen that there is a great disproportion in several of the regions between the number of Celtic forms of Univalves and of Bivalves, that whilst the Monomyaria and Dimyaria range as high as 35 and 30 per cent., the highest range of the Holostomatous univalve is only 13 and a fraction, and of the Siphonostomatous but 8, whilst the Aspiral species preserve a uniform per-centage of 6 in the three highest zones and of 3 in the three following.

Conchological Table, No. I.

Distribution of Shells in depth.

	Ægean total.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Multivalves (molluscous).	7	3	2	0	2	2	1	1	0
Patelliform univalves ..	20	11	3	2	3	5	6	6	1
Tubular univalves (Dentalia)	6	4	4	2	2	1	1	2	2
Holostomatous spiral univalves (with Bullæ and Auricula)	115	50	40	40	44	35	28	17	15
Siphonostomat. and convolute spiral univalves.	104	40	27	30	41	36	30	16	5
Testaceous Pteropoda and Nucleobranchia......	12	1	0	0	0	0	0	3	12
Brachiopoda	8	0	0	0	2	4	5	7	3
Conchifera Lamellibranchiata.............	135	38	53	52	68	58	48	34	28
	408	147	129	126	142	141	119	85	66

Conchological Table, No. II.

Distribution of Celtic forms in the several zones.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Multivalves	1	0	..	1	1	1	1	0
Patelliform univalves	0	1	2	2	2	2	2	0
Tubular univalves	1	1	0	0	0	0	0	0
Holostomatous spiral univalves	12	9	13	16	14	11	8	4
Siphonostomatous spiral univalves	4	5	7	8	9	6	5	2
Testaceous Pteropoda, and Nucleobranchia	..	..	..	..	..	..	0	0
Brachiopoda	..	..	..	0	0	0	0	0
Conchifera Lamellibranchiata	16	25	28	39	33	19	11	7
	34 = 21 per cent.	41 = 36 per cent.	50 = 45 per cent.	66 = 43 per cent.	57 = 40 per cent.	39 = 35 per cent.	27 = 36 per cent.	13 = 20 per cent.

The importance of these results must be obvious to the geologist. The inductions as to climate or distribution which he may draw from his examition of the Testacea of a given stratum, will vary according to the depth in which those Testacea lived and the ground on which they lived; for every zone of depth yields a different percentage; and as the nature of the ground determines the tribe of Testacea which frequents it, and as every tribe yields a different per-centage, according to the variation of character of the sea-bottom, so will the conclusions of the geologist vary and become uncertain. The remedy is however obvious. By carefully observing the mineral character of the stratum in order to ascertain the nature of the former sea-bottom, by noticing the associations of species and the relative abundance of the individuals of each in order to ascertain the depth, and by calculating the percentage of northern or southern forms separately for each tribe, our conclusions will doubtless approximate very nearly to the truth.

A comparison of the Testacea and other animals of the lowest zones with those of the higher exhibits a very great distinction in the hues of the species, those of the depths being for the most part white or colourless, whilst those of the higher regions, in a great number of instances, exhibit brilliant combinations of colour. The results of an inquiry into this subject are as follows:

The majority of shells of the lowest zone are white or transparent: if tinted, rose is the hue; a very few exhibit markings of any other colour. In the seventh region white species are also very abundant, though by no means forming a proportion so great as in the eighth. Brownish-red, the prevalent hue of the Brachiopoda, also gives a character of colour to the fauna of this zone: the Crustacea found in it are red. In the sixth zone the colours become brighter, reds and yellows prevailing, generally, however, uniformly colouring the shell. In the fifth region many species are banded or clouded with various combinations of colours, and the number of white species has greatly diminished. In the fourth, purple hues are frequent, and contrasts of colour common. In the third and second green and blue tints are met with, sometimes very vivid, but the gayest combinations of colour are seen in the littoral zone, as well as the most brilliant whites.

The animals of Testacea and the Radiata of the higher zones are much more brilliantly coloured than those of the lower, where they are usually white, whatever the hue of the shell may be. Thus the genus *Trochus* is an example of a group of forms mostly presenting the most brilliant hues both of shell and animal; but whilst the animals of such species as inhabit the littoral zone are gaily chequered with many vivid hues, those of the greater depth, though their shells are almost as brightly coloured as the coverings of their allies nearer the surface, have their animals for the most part of an uniform yellow or reddish hue, or else entirely white.

The chief cause of this increase of intensity of colour as we ascend is doubtless the increased amount of light above a certain depth. But the feeding grounds of the animals would appear to exert a modifying influence, and the reds and greens may be in many cases attributed to the abundance of nullipore and of the *Caulerpa prolifera*, a sea-weed of the most brilliant pea-green, the fronds of which the Mollusca of that colour, such as *Nerita viridis*, make their chosen residence.

The eight regions in depth are the scene of incessant change. The death of the individuals of the several species inhabiting them, the continual accession, deposition and sometimes washing away of sediment and coarser deposits, the action of the secondary influences and the changes of elevation which appear to be periodically taking place in the eastern Mediterranean, are ever modifying their character. As each region shallows or deepens, its animal inhabitants must vary in specific associations, for the depression which may cause one species to dwindle away and die will cause another to multiply. The animals themselves, too, by their over-multiplication, appear to be the cause of their own specific destruction. As the influence of the nature of sea-bottom determines in a great measure the species present on that bottom, the multiplication of individuals dependent on the rapid reproduction of successive generations of Mollusca, &c. will of itself change the ground and render it unfit for the continuation of life in that locality until a new layer of sedimentary matter, uncharged with living organic contents, deposited on the bed formed by the exuviæ of the exhausted species, forms a fresh soil for similar or other animals to thrive, attain their maximum, and from the same cause die off. This, I have reason to believe, is the case, from my observations in the British as well as the Mediterranean seas. The geologist will see in it an explanation of the phænomenon of interstratification of fossiliferous and non-fossiliferous beds.

Every species has three *maxima* of development,—in depth, in geographic space, in time. In depth we find a species at first represented by few individuals, which become more and more numerous until they reach a certain point, after which they again gradually diminish, and at length altogether disappear. So also in the geographic and geologic distribution of animals. Sometimes the genus to which the species belongs ceases with its disappearance, but not unfrequently a succession of similar species are kept up, representative as it were of each other. When there is such a representation the minimum of one species usually commences before that of which it is the representative has attained its correspondent minimum. Forms of representative species are similar, often only to be distinguished by critical examination. When a genus includes several groups of forms or subgenera, we may have a double or treble series of representations, in which case they are very generally parallel. The following examples from the Ægean fauna will serve to illustrate the representation in depth.

LIGULA ...	Ligula boysii.	Min. II. Max. III. Min. V.
	Ligula profundissima.	Min. VI. Max. VIII.
NUCULA	Nucula margaritacea.	Min. II. Max. IV. Min. VI.
	Nucula polii.	Min. V. Max. VIII.
	Nucula emarginata.	Min. II. Max. IV. Min. V.
	Nucula striata.	Min. IV. Max. VI. Min. VIII.
CARDIUM.	Cardium papillosum.	Min. II. Max. IV. Min. VI.
	Cardium minimum.	Min. VI. Max. VIII.
CARDITA.	Cardita calyculata.	Max. I.
	Cardita trapezia.	Min. I. Max. IV. Min. VI.
	Cardita squamosa.	Min. IV. Max. VI. Min. VIII.
ARCA ...	barbata.	Max. I.
	lactea.	Min. I. Max. IV. Min. VIII.
	scabra.	Min. IV.? Max. VII. Min. VIII.
	imbricata.	Min. V. Max. VIII.
TROCHUS	crenulatus.	Max. II. Min. III.
	exiguus.	Min. II. Max. V. Min. VII.
	ziziphinus.	Min. III. Max. IV. Min. V.
	millegranus.	Min. V. Max. VII. Min. VIII.
NASSA ...	variabilis.	Min. I.? Max. II. Min. IV.
	prismatica.	Max. IV.? Min. V.
	intermedia.	Min. V. Max. VII. Min. VIII.

In cases equally evident, but where the maxima and minima are not so definite, the succession of representations may be exemplified thus:

LIMA ...	subauriculata.	III. IV. V.
	cuneata.	V.
	elongata.	VI. VII. VIII.
RISSOA .	granulata.	I. II.
	cimicoides.	II. III. IV. V. VI.
	reticulata.	V. VI. VII. VIII.

Genera like species have a fixed maximum of development in depth, not being irregularly distributed in the several zones, but presenting their greatest assemblage of species in some one, whilst the numbers fall away more or less gradually in the preceding and following zones. In making calculations of the *maxima* of genera in depth, we must be careful to exclude all stragglers from the zones in which they may occur, otherwise our figures will be untrue. In the following table I have exhibited the specific distribution in depth of such of the Ægean genera as present the greatest number of species.

	Ægean total.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Cardium	9	2	3	3	6	3	3	1	1
Pecten	14	0	4	6	8	9	11	4	5
Bulla	14	5	6	8	8	6	2	1	2
Rissoa........	21	14	10	7	7	3	3	3	2
Trochus	28	10	10	13	10	9	7	5	1
Pleurotoma....	24	3	5	7	10	11	9	5	1
Nassa	14	3	6	4	4	1	2	1	1

The consideration of the representation in space forms an important element in our comparisons between the faunas of distinct seas in the same or representative parallels. The analogies between species in the northern and southern, the eastern and western hemispheres, are instances. But there is another application of it which I would make here. The preceding tables and list afford indications of a very interesting law of marine distribution, probable *à priori*, but hitherto unproved. The assemblage of cosmopolitan species at the water's edge, the abundance of peculiar climatal forms in the highest zone, where Celtic species are scarce, the increase in the number of the latter as we descend, and when they again diminish the representation of northern forms in the lower regions, and the abundance of remains of Pteropoda in the lowest, with the general aspect of the associations of species in all, are facts which fairly lead to an inference *that parallels in latitude are equivalent to regions in depth*, correspondent to that law in terrestrial distribution which holds that *parallels in latitude are representative of regions of elevation*. In each case the analogy is maintained, not by identical species only, but mainly by representative forms; and accordingly, although we find fewer northern species in the faunas of the lower zones, the number of forms representative of northern species is so great as to give them a much more boreal or subboreal character than is presented by those regions where identical forms are more abundant.

The consideration of the law of *representation in time* illustrates importantly the history of the very few species hitherto known only as distinct, which were discovered during the course of these researches in the Ægean. They are either such species as have had their maxima during the tertiary æra and are now fast approaching extinction, or such as had their infancy in the latest præadamic formations and are now attaining their maxima. Of the first, *Nassa substriata*, hitherto regarded as a characteristic tertiary shell, is an instance. Abounding in all the latest tertiaries of the Archipelago and of Europe generally, apparently gregarious, half a dozen straggling individuals were all that occurred in above 150 dredgings throughout the Ægean, those too in a region below their usual habitation when the species was in its prime. Of the second, *Neæra costulata* is an example; a few specimens of which only had been derived from tertiary deposits.

The result of the examination of the Ægean fauna does not hold out much prospect of the discovery of any more important extinct forms in a living state. The very few which I have been so fortunate as to discover are not such as materially to disturb the calculations of the geologist, especially if he takes into consideration the relations of each species to others and to its own maximum and minimum in time and geographic distribution. To those who have looked forward to the finding of lost forms in the greater depths of the sea, the catalogues I here present to the Association must be unsatisfactory; for though two or three such have occurred, the majority of species in the great depths are either described existing forms, or altogether new. The zero of animal life in depth has been too nearly approached to hold out further hopes. The indefatigable researches of Captain Graves and his officers have supplied me, since my return, with a mass of new data from all depths and from many new localities; but the result of their examination has been to confirm the calculations I had made from my own observations, and to lead to the pleasing hope that the researches embodied in this report will form a safe base-line for future investigations in the same department of philosophic zoology.

Were the bottom of the Ægean sea, with its present inhabitants, to be elevated and converted into dry land, or even that sea be filled up by a long series of sedimentary depositions, the evidences of its fauna which would be presented may be summed up as follows :—

1. Of the higher animals, the marine Vertebrata, the remains would be scanty and widely scattered.

2. Of the highest tribe of Mollusca, the Cephalopoda, which though poor in species is rich in individuals, there would be but few traces, saving of the Sepia, the shell of which would be found in the sandy strata forming parts of the coast lines of the elevated sea-bed,

3. Of the Nudibranchous Mollusca there would not, in all probability, be a trace to assure us of their having been; and thus, though we have every reason to suppose from analogy that those beautiful and highly characteristic animals lived in the tertiary periods of the earth's history, if not in older ages, as well as now, there is not the slightest remain to tell of their former existence.

4. Of the Pteropoda and Nucleobranchiata the shell-less tribes would be equally lost with the Nudibranchia, whilst of the shelled species we should find their remains in immense quantity characteristic of the soft chalky deposits derived from the lowest of our regions of depth.

5. The Brachiopoda we should find in deeply-buried beds of nullipore and gravel, and from their abundance we could at once predict the depth in which those beds were formed.

6. The Lamellibranchiate Mollusca we should find most abundant in the soft clays and muds, in such deposits generally presenting both valves in their natural position, whilst such species as live on gravelly and open bottoms would be found mostly in the state of single valves.

7. The testaceous Gasteropoda would be found in all formations, but more abundant in gravelly than in muddy deposits. In any inferences we might wish to draw regarding the northern or southern character of the fauna, or on the climate under which it existed, whether from univalves or bivalves, our conclusions would vary according to the depth in which the particular stratum examined was found, and on the class of Mollusca which prevailed in the locality explored.

8. The Chitons would be found only in the state of single valves, and probably but rarely, for such species as are abundant, living among disjointed masses of rock and rolled pebbles, which would afterwards go to form conglomerate, would in all probability be destroyed, as would also be the case with the greater number of sublittoral Mollusca.

9. The *Mollusca tunicata* would disappear altogether, though now forming an important link between the Mediterranean and more northern seas.

10. Of the Arachnodermatous Radiata there would not be found a trace, unless the membranous skeleton of the *Velella* should under some peculiarly favourable circumstances be preserved in sand.

11. Of the Echinodermata certain species of *Echinus* would be found entire; species of *Cidaris*, on account of the depth at which that animal lives, would be not unfrequent, in certain strata, as the region in which it is found bounds the great lowermost region of chalky mud; the spines would be found occasionally in that deposit, far removed from the bodies to which they belonged. Starfishes, saving such as live on mud or sand, would be only evidenced by the occasional preservation of their ossicula. Of the extent of their distribution and number of species no correct idea could be formed. Of the numerous *Holothuriadæ* and *Sipunculidæ* it is to be feared there would be no traces. The single Crinoidal animal would be rarely preserved entire, but its ossicula and cup-like base would be found in the more shelly deposits.

12. Of the Zoophyta the corneous species might leave impressions resembling those of Graptolites in the shales formed from the dark muds on which they live. The Corals would be few, but perhaps plentiful in the shelly beds, mostly however fragmentary. The *Cladocora cæspitosa*, where present, would infallibly mark the bounds of the sea, and from the size of its masses, might be preserved in conglomerates where the Testacea would have perished. The *Actiniæ* would have disappeared altogether.

13. Of the Sponges, traces might be found of the more siliceous species when buried under favourable circumstances.

14. The Articulata, except the shelled Annelides, would be for the most part in a fragmentary state.

15. Foraminifera would be found in all deposits, their minuteness being their protection; but they would occur most abundantly in the highest and lowest beds, distinct species being characteristic of each.

16. Tracts would be found almost entirely deficient in fossils; some, such as the mud of the Gulf of Smyrna, containing but few and scattered, whilst similar muds in other localities would abound in organic contents. On sandy deposits formed at any considerable depth they would be very scarce and often altogether absent. Fossiliferous strata would generally alternate with such as contain few or no imbedded organic remains. Whilst at present the littoral zone presents the greatest number and variety of animal and vegetable inhabitants, including those most characteristic of the Mediterranean sea, when upheaved and consolidated, their remains would probably be imperfect as compared with those of the natives of deeper regions, in consequence of the vicissitudes to which they are exposed and the rocky and conglomeratic strata in which the greater number would be imbedded. A great part of the conglomerates and sandstones found would present no traces of animal life, which would be most abundant in the shales and calcareous consolidated muds.

Supposing such an elevation of the sea-bottom of the Ægean to have taken place, a knowledge of the associations of species in the Regions of Depth would enable us to form a pretty accurate notion of the depth of water in which each bed was deposited. This I had an opportunity of exemplifying at Santorin. During a visit to that remarkable volcanic crater, in company with Lieut. Spratt, we carefully examined the little island of Neokaimeni, which came up in 1707, with a view to ascertain, if possible, the depth at which the eruption took place from any portion of the sea-bottom which might be included in its substance. Our search was successful, for imbedded in the pumice was a thin stratum of sea-bottom with its testaceous inhabitants in beautiful preservation. The following were the species:—

Pectunculus pilosus, fine and double, the valves closed; *Arca tetragona*, *Cardita trapezia*, *Cytherea apicalis*.

Trochus ziziphinus, large and fine; *T. fanulum*, *T. exiguus*, and *T. coutourii*; *Turbo rugosus* and *sanguineus*; *Phasianella pulla*, *Turritella 3-costata*, *Rissoa cimicoides*, *Cerithium lima*, *Pleurotoma gracilis*.

A *Serpula*, fragments of *Cellepora* and *Millepora*.

Now there are only two of the regions in depth in which such an association of species would be met with,—the fourth and the fifth. Had it been the sixth, *Trochus ziziphinus* would have been replaced by its representative *Trochus millegranus*. In the third *Arca tetragona* has not commenced its range, but in the fourth and fifth we found all the species named. The state of the *Pectunculus* and the *Trochus ziziphinus* indicating their *maxima*, with the numbers taken of some of the others, refer us to the fourth region as the province in which the sea-bottom on which they lived was formed, *i. e.* in a depth between twenty and thirty-five fathoms. The thinness of the layer of organic remains resting in pumice indicated that no long period had past since a former disturbance of the bottom. The state of the bivalves, their shells double and their valves closed, with the epidermis remaining, indicated that they had been suddenly destroyed, for when *Pectunculi* and *Arcæ* die naturally the valves either separate or remain gaping. They had, doubtless, been smothered in the shower of pumiceous ash which now covers them. The Bay of Santorin, close to the island in question, afforded us no soundings with 150 fathoms line, so that either a high bank, on which lived the Mollusca enumerated, existed there in 1707, before the eruption, or the bottom was uniformly such as the association of animals on it certainly indicates, in which case a depression of more than 100 fathoms must have taken place in consequence of the convulsion.

A similar application may be made of the knowledge of associations of species in depth to the elucidation of the deposits of the tertiary and even of older periods. The determination of the depth by such means is of great importance, for we have already seen how calculations as to climate and northern or southern character of fauna may mislead, unless we attain a knowledge of the region in which the strata were deposited.

The bottom of the Ægean is probably gradually shallowing. The streams which pour into it are thickly charged with sediment. The lowest depth explored was 230 fathoms. Now when the sedimentary deposit shall have filled up that region and brought it to the lowest range of the region next above, it will present a thickness of 725 feet. We have seen that this lowest region had everywhere a bottom of yellowish mud, and that similar animal forms prevailed throughout its extent. Now the strata which shall have been formed by the filling up of that region will present throughout an uniform mineral character closely resembling that of chalk, and will be found charged with characteristic organic remains and abounding in Foraminifera. We shall in fact have an antitype of the chalk. But the Ægean is far deeper through a great portion of its extent than 230 fathoms. The depth below this point will doubtless be filled with a similar mineral deposit, in places perhaps several thousand feet in thickness. But we have seen that the diminution in the number of species and of individuals as we descend in this lowest region pointed to a not far distant zero ; therefore the greater part of this immense under-deposit will in all probability be altogether void of organic remains. When indurated it would present the appearance of a great portion of the immense beds of scaglia or Apennine limestone which form such extensive districts in the South of Europe and West of Asia. This is supposing no change of level takes place during the deposition of the chalky mud. But any depression, rapid or gradual, will add to the extent of this great stratum, and by supposing such phænomenon to occur,—and the probability of its occurrence is attested by numerous examples of such in the Archipelago,—we may have a cretaceous formation produced of uniform mineral character and of indefinite thickness. On the other hand, any elevation, by raising the upper portions of the lower zone into the region next above it, will cause a correspondent change in its fauna, and if a depression ensue, we shall have an alternation of faunas, indicating very different depths and presenting very distinct zoological combinations.

Similar considerations respecting the other regions in depth must occur to the zoo-geologist who examines the facts embodied in the catalogues and tables of this report. I shall not swell its pages further by entering more at length into this attractive portion of my subject, which I leave to the consideration of more experienced inquirers, with the exception of calling attention to one other point in zoo-geology, which interested me in the course of my researches. It is this.

A very slight depression of land in the Gulf of Macri on the coast of Lycia, would now plunge below the sea muddy tracts, abounding in *Melania*, *Melanopsis*, *Neritina* and other freshwater Mollusca. Their successors in the first formed shallows would be *Cerithium mammillatum* and a few bivalves, the former mollusk in myriads. A drift of sand over this Cerithium mud would call into existence a new fauna, and every successive depression or elevation, however slight, would produce considerable zoological changes, for the subdivisions of the uppermost region are of small extent in depth, and very liable to be affected by secondary influences.

Now an inspection of the ancient monuments of the ruins of Telmessus proves that such elevations and depressions of small, but as regards animated nature, important extent, have occurred several times during the historical period; and a section of the great plain of Macri would doubtless exhibit such alternations of freshwater and marine strata with their characteristic organic contents.

In the preceding pages I have put forward several generalizations which to many may appear to be founded on inductions drawn from too limited a number of facts. The objection is, to a certain extent, true; though my data have been more numerous than would appear from this report, since the general conclusions embodied in it have not been founded only upon the observations in the Ægean, but also on a long series of researches previously conducted in the British seas. In the present state of the subject speculation is unavoidable, and indeed necessary for its advancement. If it be as important as the author believes, further researches are imperatively called for; and since this branch of inquiry, as at present conducted, may be said to have originated entirely with the British Association, he hopes that through encouragement afforded by that body, other and abler observers may be induced to enter the field, one in which the labourers require support, involving as it does time, expense and personal risk. Should the officers of the Navy and the members of Yacht Clubs take an interest in the subject, much might be done through their aid. To the surveying service the author from experience looks forward confidently for most valuable observations. Since questions of importance to navigation and commerce are intimately connected with this inquiry, it is not too much to look forward eventually to government for its support, the more so as the means of most naturalists—votaries of a science in which the pleasure of discovery is the only reward—do not warrant their adventuring privately in such researches.

Note.—In drawing up the tables of species embodied in this report, I have derived valuable assistance from several scientific friends, especially from Mr. Thompson of Belfast, who enabled me to compare my collections with a series of Mediterranean Testacea named by Michaud; from Mr. Cuming, in whose splendid collection is a series of Sicilian shells from Philippi; and from Mr. Harvey, who most kindly examined the Algæ necessary for the elucidation of the regions of depth.

APPENDIX No. I.

Examples of Dredging Papers, selected in order to show the associations of species in the several regions. The numerous dredging operations on which this Report is founded were all registered in a similar manner.

The accentuated numbers in the column of "dead specimens" refer to the disunited valves of Conchifera and Brachiopoda.

I.

Date .... May 29th, 1841.
Locality .... Nousa Bay, Paros.
Depth......................... Five to six fathoms.
Distance from shore ...... (Within the Bay.)
Ground .... Mud and sandy mud.
Region .... II.

Species.	No. of living spec.	No. of dead spec.	Observations.
Pinna squamosa......	0	1	
Modiola tulipa	1	0	In sandy mud.
Pecten polymorphus.	4	6′	
—— hyalinus.........	1	0	
Nucula margaritacea.	0	40′	In dark mud.
Cytherea chione......	0	1′	
—— venetiana	1	3–5′	
—— apicalis	1	2–12′	
Artemis lincta.........	0	1′	
Pullastra virginea ...	0	5′	
Venus verrucosa......	0	5′	
Tellina donacina	0	1–3′	
—— balaustina	0	2′	
Ligula boysii	0	2–10′	
Lucina lactea	0	2–38′	
—— squamosa	0	3′	
—— rotundata	0	4′	
Cardium rusticum ...	0	1′	A strong valve.
—— exiguum.........	3	7′	
Cardita sulcata	0	1′	Washed in from shore.
Patella scutellaris ...	0	1	
Calyptræa sinense ...	0	2	
Bulla hydatis	0	1	
Turritella 3-plicata...	0	1	
Trochus canaliculatus	0	4	
Cerithium lima	0	3	
—— vulgatum	12	8	
Murex fistulosus......	1	0	In dark mud.
Aplysia depilans......	1	0	
Ostræa plicatula......	0	10′	

Radiata.—Asterias, sp. Ophiura albida. Holothuria tubulosa. Caryophyllia cyathus. Sponges.

Several Crustacea. Five specimens of a Gobius.

Plants.—Zostera oceanica. Caulerpa prolifera. Dictyomenia volubilis. Acetabularia.

II.

Date .... September 12, 1842.
Locality .... Gulf of Smyrna, off Mouth of Hermus.
Depth......................... Seven fathoms.
Distance from shore ...... Half a mile.
Ground......................... Dark mud.
Region .... II.

Species.	No. of living spec.	No. of dead spec.	Observations.
Pecten sulcatus	0	4′	Fullgrown valves.
—— varius	0	3′	Full size.
Modiola barbata	2	2′	
Solen tenuis	1	3′	Hitherto a fossil.
—— coarctatus	0	8′	
Thracia pubescens ...	2	3′	
Ligula boysii	0	2′	
Pandora obtusa	0	4′	
Tellina donacina	5	10′	
Corbula nucleus	12	8–50′	
Cardium echinatum...	0	3′	Young specimens.
Artemis lincta	0	10′	
Montacuta, sp..........	0	1	Much worn.
Nucula margaritacea..	5	30	
—— emarginata	6	3–15′	
Dentalium 9-costatum	6	30	
Turritella terebra	6	12	
Parthenia elegantissima	0	12	
Eulima subulata	0	1	
Bulla truncatula	0	4	
—— striatula	0	6	New.
Rissoa monodonta	0	8	All young.
Ringuicula auriculata.	0	5	
Pleurotoma formicaria	0	2	
Cerithium angustissimum	0	2	
Buccinum variabile ...	0	10	
—— granulatum......	0	8	Hitherto a fossil.
Murex brandaris	0	2	
Natica pulchella	0	2	
Calyptræa sinense	2	18	

Radiata.—Amphiura chiagi. Two specimens of Chirodota. Cucumaria pentactes, 2. No Zoophytes.

Two species of Serpula. A few Annelides. Two Crustacea.

III.

Date ....Aug. 17, 1841.
Locality ....Bay of Vathy, Amorgo.
Depth....................10 to 15 fathoms.
Distance from shore ...Within the port.
Ground ....Sand, gravelly and shelly.
Region ....III.

Species.	No. of living spec.	No. of dead spec.	Observations.
Modiola tulipa.........	0	1′	
Pecten polymorphus .	1	30′	
—— opercularis......	0	3′	All very small.
Cardita trapezia	0	1′	
—— sulcata	0	3′	
Cardium exiguum	0	1′	
—— papillosum	0	50′	
Nucula margaritacea.	3	50′	
—— emarginata......	2	15	
Ligula boysii	0	50′	
Lucina transversa	0	1′	
—— lactea	0	50′	
—— hiatelloides......	3	30	
Pleurotoma attenuata	0	1	
—— ægeensis	7	1	New.
Rissoa pulchella	0	5	Hitherto a fossil.
Trochus magus	0	1	
Cerithium lima	0	60	
Nerita viridis	0	2	
Natica millepunctata .	0	2	
—— guilleminii [ma	0	1	
Parthenia elegantissi-	0	10	
Marginella clandesti-	0	1	
Bulla striatula [na	0	1	New.
—— ovulata	0	2	
Dentalium 9-costatum	1	10	

Ophioderma lacertosa, one specimen. Echinocyamus, dead. A few Crustacea.

IV.

Date ....August 29, 1841.
Locality ....Head of Cervi Bay, Morea.
Depth....................20 fathoms.
Distance from shore ...One mile.
Ground ....Weedy.
Region ....III. (commencement of.)

Species.	No. of living spec.	No. of dead spec.	Observations.
Modiola tulipa.........	1	0	A young shell.
Anomia ephippium ...	0	1′	
Pecten polymorphus .	0	4′	
—— opercularis......	2	4′	Very small.
—— pusio	1	1	Young specimens
Cytherea apicalis	0	2–3′	
Cardium exiguum.....	4	3′	
—— lævigatum	0	1	Full size.
Cardita trapezia	5	3′	
Nucula emarginata...	0	3′	
Arca lactea	16	10′	
—— tetragona	2	0	Young specimens
—— barbata	2	1	
Ligula boysii	0	1′	
Tellina balaustina	0	3′	
Hiatella arctica	2	0	
Dentalium 9-costatum	1	3	
Natica valenciensii ...	0	1	
Chiton lævis...........	1	0	
Turbo rugosus	4	1	
Trochus crenulatus...	0	1	
—— exiguus	4	2	
—— ziziphinus	0	2	
Cerithium vulgatum..	1	1	
—— lima..............	0	1	
Triforis adversum [ni	0	1	
Chenopus pes-peleca-	0	1	
Nassa prismatica	0	1	
Columbella rustica ...	0	2	
—— linnæi	0	3	
Fusus lignarius	0	1	
—— fasciolarioides...	0	2	New.
Murex cristatus	0	2	
Pleurotoma formicaria	0	1	
—— reticulata spinosa	1	0	
Mitra obsoleta.........	0	1	
—— savignii [træoides	0	2	
Pleurobranchus calyp-	0	2	In crevices of sponge.

1 Asterias. 2 Ophioderma lacertosa.
Many sponges, annellides and corallines.

V.

Date ....Sept. 14, 1842.
Locality ....Gulf of Smyrna.
Depth....................26 fathoms.
Distance from shore ...Two miles and a half.
Ground ....Fine brown mud.
Region ....III.

Species.	No. of living spec.	No. of dead spec.	Observations.
Avicula tarentina......	3	3′	Full grown, adhering to each other.
Hiatella arctica	4	0	

Amphiura chiagii.
Plumulariæ and other Sertulariadæ adhering, with small sponges, to the Aviculæ.

VI.

Date ....Sept. 16, 1842. [Smyrna.
Locality ....Off Long Island, Gulf of
Depth....................28 fathoms.
Distance from shore ...One mile and a half.
Ground ....Yellow sand.
Region ....III.

Species.	No. of living spec.	No. of dead spec.	Observations.
Lucina spinifera	1	2′	
Ligula prismatica	0	3	
Pandora obtusa	0	3	
Astarte pusilla?	1	0	

Sertularian zoophytes.
Ophiura texturata. Comatula mediterranea.

Note.—The two preceding dredges are examples selected from many such, of unprolific tracts in a region usually fertile in living inhabitants. In this case a sea-bottom derived from the debris of fresh water tertiary formations seems to be the negative influence.

VII.

Date ....Dec. 1, 1841.
Locality ....Port of Sumboli under Cra-
Depth....................30 fathoms. [gus, Lycia.
Distance from shore ...Within the basin.
Ground ....Ash-coloured mud.
Region ....IV.

Species.	No. of living spec.	No. of dead spec.	Observations.
Modiola tulipa.........	0	1′	It will be observed, that among the many testacea taken in this dredge, only two species occurred alive. The locality is a deep basin with a very shallow and narrow entrance, an indurated bar of sand and pebbles having formed across an inlet, the consequence of which has probably been the destruction of the greater number of mollusca which formerly inhabited it.
Lima tenera...........	0	1′	
Pecten jacobæus	0	frag.	
—— polymorphus ...	0	10′	
—— opercularis	0	2′	
Ostræa plicatula, jun.?	0	10′	
Arca noæ..............	0	frag.	
Pectunculus lineatus..	0	1′	
Nucula emarginata ...	0	2′	
—— margaritacea ...	0	12′	
Cardita sulcata	0	1′	
—— trapezia	0	1′	
Cardium lævigatum...	0	1′	
—— papillosum	0	10′	
—— exiguum	0	3′	
—— echinatum	0	20′	
Venus ovata...........	0	2′	
—— incompta?	0	1′	
Cytherea venetiana...	0	2′	
—— apicalis	0	12′	
Lucina spinifera	0	10′	
—— sinuosa	0	1′	
—— commutata	0	1′	
Tellina donacina	0	2′	
Saxicava arctica	0	2	
Thracia pubescens ...	0	frag.	
Corbula nucleus	20	40′	
Ligula prismatica	0	6′	
—— boysii	0	4′	
Solen coarctatus [mis	0	6′	
Gastrochænacuneifor-	0	2′	
Murex brandaris	0	frag.	
Aporrhaispes-pelecani	0	2	
Cerithium vulgatum..	0	1	
—— lima..............	0	5	
Conus mediterraneus.	0	frag.	
Turritella 3-plicata ...	0	1	
Rissoa cimex	0	2	
Trochus exiguus	0	1	
—— contourii.........	0	1	
—— sanguineus	0	1	
Natica pulchella	0	1	
Bulla hydatis	0	1	
Dentalium 9-costatum	2	5	
Bulimus acutus	0	1	

Leaves of olive and of Quercus coccifer were found imbedded in the mud. No zoophytes occurred.

VIII.

Date ....August 5. [Paros.
Locality ....Off northern extremity of
Depth....................40 fathoms.
Distance from shore ...Three miles and a half.
Ground ....Weedy.
Region ....V.

Species.	No. of living spec.	No. of dead spec.	Observations.
Pecten pusio	5	4′	
—— opercularis	0	1	Small.
Nucula margaritacea .	0	2′	
Cytherea apicalis......	0	1′	
Cardita squamosa	1	1′	
Cardium papillosum..	0	2	
Fusus fasciolarioides .	1	0	New.
Murex brandaris	0	3	
Vermetus gigas	0	1	
—— corneus	3	0	New.
Trochus exiguus	8	2	
Turbo rugosus [dus	1	0	
Pleurobranchus sordi-	1	0	New.
Doris tenerrima	2		New.
—— gracilis	2		
—— coccinea	1		
Ascidia, four species.			
Aplidium, two species.			

Echinocyamus, alive and dead. Plumularia. Several Crustacea.
Codium tomentosum.

IX.

Date ....October 11, 1841.
Locality ....Off Cape Crio, Asia Minor.
Depth....................55 to 70 fathoms.
Distance from shore ...Three-fourths of a mile.
Ground ....Millepore.
Region ....VI.

Species.	No. of living spec.	No. of dead spec.	Observations.
Pecten pes-felis	0	frag.	
—— hyalinus	0	1′	
—— pusio	0	2′	
Venus ovata...........	0	1′	
Cytherea apicalis......	0	2–2′	
Lucina bipartita	0	3′	
Astarte incrassata	0	4′	
Cardita trapezia	0	2′	
Arca barbata	0	1′	
—— lactea	0	1′	
Terebratula truncata .	10	6–8′	
—— detruncata	18	30–10′	
—— seminulum	2	0	
Crania ringens.........	20	8′	
Fusus lavatus	5	2	
—— crispatus.........	0	3	Hitherto only fossil.
—— turritellatus	2	5	
Pleurotoma	0	frag.	
Columbella linnæi ...	0	2	
Cerithium lima	0	2	

Species.	No. of living spec.	No. of dead spec.	Observations.
Triforis adversum	0	1	
Mitra obsoleta	0	3	
—— granum	0	1	New.
—— ebenus	0	2	
Murex cristatus	0	1	
Trochus fanulum......	0	1	
Turbo sanguineus	0	2	
Turritella 3-plicata ...	2	3′	
Natica valenciensii ...	0	frag.	
Cypræa europæa [mis	0	1	
Emarginula capulifor-	0	2	
Lottia unicolor	1	3	
Chiton rissoi	1	0	
—— lævis	1	0	
—— fascicularis	1	0	
—— frelandi	1	0	A new species.

Goniaster, sp., 1 spec. Asterina, sp., 3 spec.
Echinus monilis, many specimens. Cidaris histrix, abundant, alive.
Echinocyamus, many specimens.
Myriapora truncata, alive.
A small yellow Goby.

X. (by Lieut. Spratt.)

Date ....July, 1842.
Locality ....Off east coast of Naxia.
Depth.....................80 to 95 fathoms.
Distance from shore ...Three miles from N.E. Cape.
Ground ....Nullipore.
Region ....VII.

Terebratula truncata .	1	0	
—— detruncata	18	6	
Pecten varius	6	4′	All small.
—— opercularis	0	1′	A small valve.
—— testæ	1	2′	
Lima elongata	0	1′	Young and small, apparently frag. of M. barbata.
Modiola	0	2	
Hiatella arctica	1	0	
Cardita aculeata	0	1′	
Astarte incrassata ?...	0	1′	
Cytherea apicalis......	3	3′	
Venus ovata...........	1	2′	
Arca tetragona.........	1	1′	Small.
—— scabra	0	2	Small.
Murex cristatus, var..	4	2	
Pleurotoma maravig-	1	2	
—— gracilis [næ	1	0	
—— crispata	1	1	Hitherto fossil.
—— reticulata	0	1	
—— formicaria	1	0	
Cerithium lima	2	6	
Trochus exiguus	2	1	
Phasianella pulla......	1	0	
Rissoa reticulata	1	3	
—— ventricosa	1	0	A straggler?
Turbo rugosus.........	2	0	
Natica pulchella	0	1	

Species.	No. of living spec.	No. of dead spec.	Observations.
Tornatella fasciata ...	1	0	Well grown.
Emarginula elongata .	0	1	
Chiton lævis	1	0	

Annelides.—Serpulæ.
Crustacea.—Some small species.
Radiata.—Echinus monilis and Echinocyamus pusillus. Species of Cidaris.

XI.

Date ....July, 1841.
Locality ....Off Serpho-Poulo.
Depth.....................95 fathoms.
Distance from shore ...Two miles.
Ground ....Millepore.
Region ....VII.

Terebratula truncata .	0	6–4′	
—— detruncata	30	10–6′	
—— lunifera	1	0	
Crania ringens.........	0	35′	
Lima elongata	0	2′	New.
—— crassa	0	3′	New.
Modiola	1	1′	Very young.
Pecten testæ	0	1–3′	
—— concentricus ...	2	4′	New.
—— similis...........	0	6′	
Cardita squamosa	1	7′	
Cytherea apicalis......	0	2′	
Venus ovata	0	4′	
Astarte pusilla.........	0	2	New.
Lucina commutata ...	0	1′	
—— bipartita	0	1′	
Arca lactea	4	6′	
Pleurotoma crispata..	1	3	Hitherto known only fossil.
—— abyssicola........	0	3	New.
—— marivignæ	1	7	
—— reticulata	1	1	
—— minuta	0	4	New.
Fusus muricatus	0	5	
Triforis perversum ...	0	1	
—— lima	0	7	
Turritella 3-costata ..	0	2	
Trochus exiguus	0	2	
Turbo sanguineus	0	2	
Rissoa reticulata [na	6	36	
Marginella clandesti-	0	2	
Tornatella pusilla	0	1	New.
Emarginula elongata .	0	1	
—— capuliformis ...	0	2	
Fissurella græca	0	1	
Cleodora pyramidata .	0	1	

Two species of sponge.
Several zoophytes, including Caryophyllia.
Echinocyamus, alive. Echinus monilis, alive and dead.
Several small Crustacea.

XII.

Date ....Sept. 16, 1841.
Locality ....Off Ananas Rocks.
Depth......................105 fathoms.
Distance from shore ...From rocks three miles, from [Milo ten miles.
Ground ....Nullipore.
Region ....VII.

Species.	No. of living spec.	No. of dead spec.	Observations.
Terebratula vitrea	0	2′	Dead and worn.
—— truncata	30	100-20′	Of all ages.
—— detruncata	100–	400-6′	Of all ages.
—— seminulum	18	10-8′	
—— appressa	1	0	Adhering to T. vitrea. New.
Crania ringens.........	0	6′	
Lima elongata	0	5′	New.
Pecten concentricus ..	0	1′	New.
—— fenestratus	0	2′	New.
Spondylus gussonii ...	1	1′	
Arca lactea	1	7′	
—— scabra............	0	2′	
Neæra cuspidata	0	1′	
—— attenuata	0	1′	New.
Fusus echinatus	0	2	
Pleurotoma crispata ..	0	2	Hitherto known only fossil.
—— marivignæ	0	2	New.
—— abyssicola	0	4	New.
Mitra phillipiana......	0	4	New.
Cerithium lima	0	8	
Trochus tinei	0	6	
—— exiguus	1	9	Hitherto known only fossil in the Mediterranean basin.
Turbo sanguineus	0	24	
Rissoa reticulata	4	11	
Emarginula elongata .	0	8	
Pileopsis hungarica ...	0	1	Small.
Lottia unicolor	1	24′	New.
Atlanta peronii	0	2	Encrusted with nullipore, and thus rendered solid.
Hyalæa gibbosa	0	1′	
Cleodora pyramidata .	0	3′	
Criseis clava	0	7	
—— spinifera	0	10	

Pectinura vestita, one (new). Echinocyamus, many, dead. Young Cidaris, alive. Echinus monilis, alive and dead. Four species of zoophyte. Several species of Serpula. Fragment of a Balanus. Small crabs. Foraminifera.

XIII.

Date ....Sept. 2.
Locality ....Channel between the Morea [and Cerigo.
Depth......................110 fathoms.
Distance from shore ...Three miles from Cervi [coast.
Ground ....Sandy mud.
Region ....VIII.

Species.	No. of living spec.	No. of dead spec.	Observations.
Pecten similis	0	10′	New to Mediterranean.
Lima elongata.........	0	3′	New.
Lima crassa	0	4′	New.
Nucula polii............	0	5′	
—— striata............	1	6′	
Arca lactea	0	1′	Young shell.
Poromya anatinoides .	0	2′	New.
Neæra costellata	2	4′	
—— cuspidata	1	2′	
Hiatella rugosa	0	frag.	Full grown.
Pandora obtusa	0	3′	
Kellia abyssicola	0	8′	New.
Cardium minimum ...	0	3′	
Rissoa reticulata	0	6	
Bulla utriculus.........	0	1	
Trochus millegranus .	1	1	
Parthenia ventricosa .	0	1	New.
Dentalium quinquan-[gulare	0	4	Hitherto fossil.
Atlanta peronii	0	3	
Ladas planorboides...	0	2	
? Limacina minuta ...	0	3	
Hyalæa gibbosa	0	3	
—— vaginellina	0	1	
Cleodora pyramidata .	0	4	
3 species of Criseis ?..	0	...	Abundant.

Annelides.—Ditrupa subulata and pusilla, the latter alive.
Crustacea.—Several small species.
Radiata.—Amphiura chiagi. Spines of Cidaris.

XIV.

Date ....August 2, 1841.
Locality ....Off Island of Amorgo.
Depth......................140 fathoms.
Distance from shore ...Ten miles.
Ground ....White mud with fragments [of pumice.
Region ....VIII.

Species.	No. of living spec.	No. of dead spec.	Observations.
Anomia polymorpha .	0	1–4	Perhaps a strag-[gler.
Lima elongata.........	0	12′	New.
—— crassa	0	5′	New.
Pecten similis	0	30′	New to Mediter-[ranean.
—— dumasii	0	1′	
—— fenestratus	0	2′	New.
Nucula polii............	0	1′	
Arca tetragona	1	1	
—— lactea	0	10′	
Cardium minimum ...	0	1′	
Kellia abyssicola......	3	2–4′	New.
Ligula profundissima.	2	5–17′	New.
Neæra costellata	0	7′	Hitherto known [only fossil.
—— cuspidata	1	12′	
Murex vaginatus......	0	1	Hitherto known [only fossil.
Cerithium lima	0	1	A straggler.
Rissoa ovatella	0	1	New.
Parthenia ventricosa .	0	1	New.
Eulima subulata	0	1	
—— distorta	0	1	
Dentalium quinquan-[gulare	2	30	
Bulla utriculus	0	1	
Carinaria mediterra-[nea	0	1	Small.

Species.	No. of living spec.	No. of dead spec.	Observations.
Atlanta peronii	0	6	
? Limacina minuta	0	8	New.
Hyalæa gibbosa	0	10	
—— vaginellina	0	1	
Criseis clava	0	40	
—— spinifera	0	100	
—— striata	0	4	

Idmonea and another zoophyte.
Ophiura abyssicola, alive.
Fragments of a Brissus. Serpula, one species; Ditrupa pusilla, and three species of Crustacea.

XV.

Date .... Sept. 17, 1841.
Locality .... Off Milo.
Depth..................... 150 fathoms.
Distance from shore ... Four miles.
Ground .... Fine white sandy mud.
Region .... VIII.

Species.	No. of living spec.	No. of dead spec.	Observations.
Pecten similis	0	30′	New to Mediter-
—— concentricus	0	2′	[ranean
—— dumasii	0	frag.	
Lima elongata	0	8′	New.
—— crassa	0	8′	New.
Arca lactea	0	10′	
—— scabra	0	1′	
Poromya anatinoides	0	1′	New.
Kellia abyssicola	0 ?	10–50′	New.
Neæra cuspidata	0	2′	[only as fossil.
—— costellata	0	3′	Hitherto known
—— abbreviata	0	2′	New.
Cardita squamosa	0	1′	A young valve.
Ligula profundissima.	0	1–15′	
Crania ringens [ta	0	2′	
Terebratula detrunca-	0	2	Stragglers.
Murex vaginatus	0	1	And two frag-
Fusus muricatus [na	0	4	ments (hitherto
Marginella clandesti-	0	1	fossil).
Rissoa reticulata	0	12	
—— ovulata	0	2	
Parthenia ventricosa	0	1	New.
Cerithium lima	0	1	Straggler ?
Lottia unicolor	0	1	
Scissurella plicata	0	3	
Peracle physoides	0	3	
Hyalæa gibbosa	0	22	
—— vaginellina	0	1	
—— cornea	0	2	
Cleodora pyramidata	0	many	
——	0	2	

Criseis, the three species abundant.

XVI.

Date .... Dec. 23, 1843. [Asia Minor.
Locality .... S.E. side of Gulf of Macri,
Depth..................... 185 fathoms.
Distance from shore ... Two miles.
Ground .... Pale yellowish mud.
Region .... VIII.

Species.	No. of living spec.	No. of dead spec.	Observations.
Pecten concentricus	0	3′	New.
—— hoskynsi	0	4′	New.
—— similis	0	3′	
Arca imbricata	1	18′	
Nucula striata	0	2′	
—— ægeensis	1	6–5′	New.
Kellia abyssicola	4	20′	New.
Neæra cuspidata	1	3′	[only fossil.
—— costellata	1	8	Hitherto known
—— abbreviata	0	3	New.
Ligula profundissima.	1	3–15′	
Pleurotoma abyssicola	0	3	New.
Nassa intermedia, var.	0	3	New.
Rissoa reticulata [na	0	12	Hitherto fossil only in Mediterranean, recent in North Seas.
Marginella clandesti-	0	3	
Dentalium quinquan-	0	36	
Hyalæa cornea [gulare	0	frag.	
—— gibbosa	0	3	
—— vaginellina	0	1	
Cleodora pyramidata	0	12	
Criseis clava	0	many	
—— spinifera	0	many	
—— striata	0	many	
? Limacina minuta	0	many	New.
Carinaria mediterra-	0	1	
Peracle physoides [nea	0	10	New.

Many *Nodosariæ* and other Foraminifera. The carapace of a crab. A very small living sponge. Arms of *Amphiura chiagii*.

XVII.

Date... .... Nov. 25, 1841. [Asia Minor.
Locality .... S. extremity of Gulf of Macri,
Depth..................... 230 fathoms.
Distance from shore ... One mile (shore steep).
Ground .... Fine yellowish mud.
Region .... VIII.

Terebratula vitrea	0	2′	
Ligula profundissima.	0	3′	New.
Arca imbricata [gulare	1	1′	
Dentalium quinquan-	1	0	
Hyalæa gibbosa	0	1	
Cleodora pyramidata	0	8	
Criseis spinifera	0	5	

A glassy Serpula, and the corneous tube of an Annelide adhered to the Terebratula; also a species of Alecto and a Lobatula.

APPENDIX No. II.

Brief Diagnoses of new species of Mollusca named in the preceding tables. The new Radiata are described in the Linnæan Transactions.

Order NUCLEOBRANCHIATA.

Genus LADAS, *Cantraine.*

Ladas planorboides, sp. nov.

L. testâ pellucidâ, albâ, lævi, compressâ, carinatâ, exalatâ, anfractibus 4.

Diam. $0\frac{1}{12}$. Reg. VIII. (frequent.)

Genus PERACLE, *Forbes.*

(I propose this genus for certain small reversed, spiral shells, having the aperture more or less prolonged into a pointed canal. Fuller details will be given elsewhere.)

Peracle physoides, sp. nov.

P. testâ ovatâ, albâ, pellucidâ (epidermide? reticulatâ); caudâ longâ, arcuatâ, acutissimâ.

Long. $0\frac{1}{12}$. Reg. VIII. Cyclades, Lycia.

? *Bellerophina minuta.*

I have enumerated among the Nucleobranchiata a shell under this name, which I have now good reason to believe is the shell of the larva of (perhaps many) species of several orders of Mollusca. It is extremely minute, helicoid, transparent, and of two or three whorls. It abounds in the mud from very deep water.

GASTEROPODA.

Order NUDIBRANCHIA.

Fam. *Doridæ.* Genus DORIS, *Lin.*

Doris aurata, sp. nov.

D. corpore ovali, convexo, lævi, succineo, maculis stellatis albis; branchiis 5—6, flavidis; tentaculis aurantiacis apicibus flavis; pede flavo.

Long. $0\frac{3}{4}$ unc. *Hab.* 50 fathoms. Paros (Lieut. Mansell).

Genus GONIODORIS, *Forbes.*

Goniodoris regalis, sp. nov.

G. corpore elongato, lanceolato, plano, lævi; dorso viridi, longitudinaliter flavo-vittato, albo-marginato; lateribus griseis flavo-maculatis; pede albo; branchiis 10—12, viridibus, flavo-marginatis; tentaculis azureis.

Long. 4 unc. *Hab.* Littoral. Port Massini, Skanousi. (Lieut. Freeland.)

Goniodoris tenerrima, sp. nov.

G. corpore cuneato, alto, dorso lateribusque griseis lineis interruptis albis cœruleisque pictis; margine flavo; pede angustissimo albo; branchiis 10—12, griseis, pedunculatis; tentaculis azureis.

Long. 3 unc. *Hab.* 4 miles from Paros in 40 fathoms, weedy ground.

Goniodoris vivida, sp. nov.

G. corpore subquadrato cœruleo, dorso fasciâ centrali albâ, albo marginato; branchiis 7, cœruleis.

Long. $0\frac{3}{10}$ unc. *Hab.* 7—30 fathoms, weedy ground, Cyclades.

Fam. *Melibœadæ.* Genus MELIBŒA, *Rang.*

Melibœa? minuta, sp. nov.

M. corpore oblongo, flavido, lateribus in branchiis binis rotundatis lobiformis productis.

Long. $0\frac{3}{24}$. *Hab.* 5 fathoms. Despotico.

The form of the branchiæ approaches those of *Scyllæa*, whilst the tentacula are characteristic of *Melibœa*. This minute nudibranc may possibly belong to an intermediate genus.

Order INFEROBRANCHIATA.

Fam. *Pleurobranchaceæ*. Genus PLEUROBRANCHUS, *Cuv.*

Pleurobranchus limacoides, sp. nov.

P. corpore (repente) oblongo, lævi, aurantiaco; pallio ovato plano, contra-subemarginato; caudâ exsertâ lanceolatâ; tentaculis elongatis, linearibus.

Long. $2\frac{3}{4}$ unc. *Hab.* under stones near water-mark among the Cyclades. Allied to *P. oblongus* of Cantraine.

Pleurobranchus calyptræoides, sp. nov.

P. corpore ovato, lævi, citrino, pallio orbiculari convexo, caudâ exsertâ latâ obtusâ, tentaculis linearibus.

Long. $1\frac{1}{4}$ unc. *Hab.* on sponges, 20 fathoms, Cervi Bay, Morea.

Pleurobranchus scutatus, sp. nov.

P. corpore rotundato, rubro-aurantiaco; pallio lato scabro, convexo, anticè producto; caudâ pallio occultâ; tentaculis linearibus.

Long. 1 unc. *Hab.* on *Codium tomentosum*, in 20 fathoms, Cyclades.

Pleurobranchus sordidus, sp. nov.

P. corpore rotundato convexo; pallio rugoso, sordidè brunneo, anticè producto; pede quadrato, albo; caudâ brevissimâ; tentaculis albis linearibus; ore aurantiaco.

Long. $0\frac{3}{4}$ unc. *Hab.* 40 fathoms off Paros.

Order TECTIBRANCHIATA.

Fam. *Aplysiaceæ*. Genus APLYSIA, *Lin.*

Aplysia saltator, sp. nov.

A. corpore globoso, griseo albo nigroque maculato, tuberculato, tuberculis mucronatis; sinu branchiali parvo; pede angustissimo, tentaculis brevibus.

Long. 2 unc. Alt. $1\frac{2}{10}$. *Hab.* 20—30 fathoms. Serpho Bay.

Genus ICARUS, *Forbes.*

(The animal for which I propose to constitute the genus *Icarus* differs from *Aplysia* in having but two tentacula, and in being prolonged posteriorly into a slender lanceolate tail. The dorsal shield resembles the shell of a *Bullæa*. A full account of the genus will be published elsewhere.)

Icarus gravesi, sp. nov.

Animal viridum purpureo, alboque variegatum. *Testa* alba, pellucida.

Long. $1\frac{7}{12}$ unc. Long. test. $5\frac{5}{12}$ unc. Syra, Serpho.

Fam. *Aceridæ*. Genus BULLÆA, *Lamarck.*

Bullæa alata, sp. nov.

B. testâ orbiculari, spiraliter punctato-striatâ, labro expanso, spiram excedente, margine integro.

Long. and lat. $0\frac{3}{24}$. Suda Bay, Candia, in 119 fathoms. (Capt. Graves, 1843.)

Genus BULLA, *Lin.*

Bulla retifer, sp. nov.

B. testâ oblongâ, laxè convolutâ, longitudinaliter transversimque striatâ, epidermide reticulato-vestitâ, spirâ truncatâ, umbilicatâ, aperturâ ovatâ supernè coarctatâ; columellâ marginatâ.

Long. $0\frac{3}{12}$. Lat. $0\frac{2}{12}$ unc. Serpho.

Bulla striatula, sp. nov.

B. testâ oblongâ, cylindricâ, lacteâ, transversè undulato-striatâ, longitudinaliter obsoletè striatâ, vertice subtruncato concavo; spirâ manifestâ; aperturâ supernè lineari, infernè dilatatâ.

Long. $0\frac{3}{24}$ unc. Rio, Macri, Servi, Crete, &c.

Bulla turgidula, sp. nov.

B. testâ inflatâ, ovatâ, albâ, politâ, infernè supernèque transversè striatâ, medio lævissimo; apice truncato, umbilicato, margine crenato; spirâ occultâ; aperturâ angustâ, utrinque subrostratâ.

Long. $0\frac{3}{24}$ unc. Servi, Amorgo.

Bulla cretica, sp. nov.

B. testâ globosâ, albâ, lævigatâ, spirâ manifestâ, umbilicatâ, margine rotundatâ; aperturâ supernè contractâ, infernè dilatatâ; columellâ perforatâ.

Long. $0\frac{1}{10}$ unc. Crete in 119 fathoms. (Capt. Graves, 1843.)

Order SCUTIBRANCHIATA.

Fam. *Patelloideæ*. Genus LOTTIA, *Gray*.

PATELLOIDEA, *Quoy* and *Gaim*. ACMÆA, *Hartman*.

Lottia unicolor, sp. nov.

L. testâ parvâ, rotundatâ, subconicâ, lævigatâ, rubrâ, apice centrali.

Long. $0\frac{3}{12}$ unc. Asia Minor, Crete, Cyclades.

Order CYCLOBRANCHIATA.

Fam. *Chitonidæ*. Genus CHITON, *Lin*.

Chiton freelandi, sp. nov.

C. valvulis omnibus granulatis, carinatis, areis inferioribus elevatis longitudinaliter obsoletè excavatis; areis superioribus depressis transversè profundè sulcatis; carinâ lævigatâ; margine squamoso, squamis tessellatis.

Long. $0\frac{1}{2}$ unc. Lat. $0\frac{3}{12}$ unc. Caria, Delos, Crete (in deep water).

Order CIRRHOBRANCHIATA.

Genus DENTALIUM, *Lin*.

Dentalium quinquangulare, sp. nov.

C. testâ arcuatâ, albâ, longitudinaliter striatâ, pentangulari.

Long. $0\frac{5}{12}$. Everywhere in the deepest region.

Order PECTINIBRANCHIATA.

Fam. *Scalariadæ*. Genus EULIMA, *Risso*.

Eulima unifasciata, sp. nov.

E. testâ turritâ, lævigatâ, politâ, albâ, fasciâ fulvâ cinctâ; anfractibus 11, planiusculis; aperturâ ovatâ.

Long. $0\frac{3}{12}$ unc. Lycia. Reg. VIII.

Genus PARTHENIA, *Lowe*.

= TURBONILLA, *Risso*, PYRGISCUS, *Philippi*, = CHEMNITZIA, *d'Orbigny*.

Parthenia ventricosa, sp. nov.

P. testâ turritâ, acutâ, albâ, pellucidâ, lævi, politâ; anfractibus 9 tumidis, aperturâ subquadratâ, columellâ rectâ, subumbilicatâ.

Long. $0\frac{3}{24}$ unc. Cerigo, Cyclades, Lycia. Reg. VIII.

Parthenia turris, sp. nov.

P. testâ aciculatâ, albâ, pellucidâ, lævi, politâ; anfractibus 11 convexis, aperturâ subquadratâ, columellâ rectâ, imperforatâ.

Long. $0\frac{2}{12}$ unc. Cyclades. Reg. VIII.

Parthenia fasciata, sp. nov.

P. testâ turritâ, albâ, fasciâ flavâ; anfractibus 7, planis, ad suturas subangulatis, longitudinaliter costatis, ultimo anfractu 16-costato, basi subangulato, lævi; aperturâ quadrangulari.

Long. $0\frac{2}{12}$ unc. Cyclades, Lycia. Reg. VIII.

Parthenia varicosa, sp. nov.

P. testâ turritâ, albidâ, fasciis fulvis; anfractibus 11 convexis, varicosis, spiraliter striatis, longitudinaliter (18—20) costatis, basi rotundato, ecostulato, aperturâ subquadratâ.

Long. $0\frac{1}{2}$. Lat. $0\frac{3}{24}$ unc. Cyclades.

Genus Rissoa, *Trem.*

Rissoa cimicoides, sp. nov.

R. testâ ovato-conicâ, albidâ, anfractibus 7 convexiusculis, sulcis longitudinalibus spiralibusque granulato-decussatis, ad suturam marginatis, crenulatis; aperturâ ovatâ, labro externo incrassato.

Long. $0\frac{2}{12}$ unc. Crete, Cyclades, Lycia, Smyrna.

Rissoa ovatella, sp. nov.

R. testâ oblongâ, albâ, anfractibus 5, spiraliter punctato-striatis; aperturâ ovatâ infernè angulatâ; columellâ rectâ.

Long. $0\frac{5}{24}$ unc. Cyclades, Asia Minor.

Rissoa pulchra, sp. nov.

R. testâ turritâ, albâ, anfractibus 6 convexis, longitudinaliter sulcato-striatis (striis 19), suturis profundis; aperturâ ovatâ, labro simplici.

Long. $0\frac{1}{10}$ unc. Paros.

Genus Scalaria, *Lam.*

Scalaria hellenica, sp. nov.

S. testâ turritâ, albâ, imperforatâ, anfractibus 10 convexis, varicosis, spiraliter striatis longitudinaliter costatis, costis rotundatis crassiusculis, in ultimo anfractu 10; aperturâ marginatâ, margine radiato-crenato.

Long. $0\frac{2}{10}$ unc. Cervi.

Genus Turritella, *Lam.*

Turritella suturalis, sp. nov.

T. testâ elongatâ, albâ, anfractibus ventricosis, spiraliter pauci-costatis, ad suturas excavatis, lævigatis.

Long. $\frac{3}{12}$. Caria.

Fam. *Siliquariadæ.* Genus Vermetus, *Adanson.*

Vermetus corneus, sp. nov.

V. testâ tenui, corneâ, pellucidâ, tereti, transversè corrugatâ, striatâque.

Long. 3 unc. Lycia, Cyclades, Crete.

Fam. *Trochidæ.* Genus Trochus, *Lin.*

Trochus pallidus, sp. nov.

T. testâ conoideâ, latâ, griseâ maculis obscuris, anfractibus 5—6 spiraliter striatis (sub lente striis longitudinalibus), ad suturas planiusculis, ultimo in medio subexcavato, basi plano angulato; umbilico profundo, albo, margine acuto.

Alt. $0\frac{4}{12}$. Lat. bas. $0\frac{6}{12}$ unc. Amorgo.

Trochus lyciacus, sp. nov.

T. testâ conoideâ, latâ, albidâ, purpureo maculatâ (ad umbilicum flammulatâ), anfractibus 5—6 spiraliter sulcatis, sulcis transversè striatis, ad suturam planatis, in medio excavatis; basi plano, marginato; umbilico parvo; aperturâ quadrangulari, columellâ incrassatâ.

Alt. $0\frac{7}{24}$. Lat. bas. $0\frac{9}{24}$ unc. Lycia, Peræa.

Trochus spratti, sp. nov.

T. testâ conoideâ, nigro-brunneâ, maculis albis tessellatâ; anfractibus 6 convexis spiraliter sulcatis, transversè obliquè striatis, ad suturam planiusculis; basi margine rotundato; umbilico parvo, albo; aperturâ subquadratâ.

Alt. $0\frac{7}{24}$. Lat. bas. $0\frac{7}{24}$ unc. Servi, Cyclades, Lycia, Smyrna.

Trochus gravesi, sp. nov.

T. testâ conicâ, albâ, brunneâ, maculis albidis, epidermide iridescente, anfractibus 8 planis, spiraliter transversèque striatis, infernè ad suturam bicingulatis, cingulis planiusculis, crenulatis; basi margine subangulato, spiraliter sulcato, radialiter striato; umbilico nullo; aperturâ subquadratâ.

Alt. $0\frac{5}{12}$. Lat. bas. $0\frac{3}{12}$ unc. Cyclades, Morea, Lycia.

Fam. *Cerithiadæ*. Genus CERITHIUM, *Brug.*

Cerithium angustissimum, sp. nov.

C. testâ lineari, anfractibus 13, convexis, longitudinaliter costatis, spiraliter 4-sulcatis, ad suturam marginatis.

Long. $0\frac{3}{12}$. Lat. $0\frac{1}{24}$ unc. Sporades.

Fam. *Muricidæ*. Genus PLEUROTOMA, *Lam.*

Pleurotoma teres, F., v. Reeve, Conchologia Iconica.
" *turgida*, F., loc. cit.
" *fortis*, F., loc. cit.
" *lyciaca*, F., loc. cit.
" *minuta*, F., loc. cit.
" *abyssicola*, F., loc. cit.
" *ægeensis*, F., loc. cit.
" *fallax*, F., sp. nov.

P. testâ fusiformi, fulvâ, fasciâ albidâ, anfractibus 8, tumidis, longitudinaliter (16) costatis, spiraliter sulcato-striatis, suturis impressis, aperturâ ovato-lanceolatâ, caudâ brevi, latâ.

Long. $0\frac{1}{2}$ unc. Paros.

Genus FUSUS, *Lam.*

Fusus fasciolarioides, sp. nov.

F. testâ oblongâ, aurantiâ fasciâ interruptâ albâ, anfractibus 5, spiraliter striatis, noduloso-(9) costatis, ad suturas appressis, ultimo subangulato; aperturâ lanceolatâ, canali obliquâ, longiusculâ.

Long. $0\frac{5}{12}$. Lat. $0\frac{5}{24}$. Apert. $0\frac{5}{24}$ unc. Cyclades, Lycia.

Fusus karamanensis, sp. nov.

F. testâ elongatâ, succineo-brunneâ, fasciâ centrali angustâ flavâ, albo maculatâ, anfractibus 7, angulatis, longitudinaliter 7-costatis, costis in carinam tuberculatis; aperturâ lanceolatâ, canali latiusculo.

Long. $0\frac{13}{24}$. Lat. $0\frac{5}{24}$. Apert. $0\frac{6}{24}$ unc. Lycia.

Genus MUREX, *Lin.*

Murex brevis, sp. nov.

M. testâ albâ, ovato-ventricosâ, subumbilicatâ, anfractibus 6 (ultimo maximo), longitudinaliter 8-costatis, spiraliter costato-striatis, costis spiralibus numerosis, alternatis majoribus, omnibus squamosis; canali brevi, angusto, labro externo fimbriato-plicato.

Long. $0\frac{10}{12}$. Lat. $0\frac{1}{2}$. Apert. $0\frac{1}{2}$ unc. Paros, Crete.

Genus NASSA, *Lam.*

Nassa intermedia, sp. nov.

N. testâ ovato-oblongâ, ventricosâ, albâ fasciâ flavâ, anfractibus 6, ultimo spiram excedente, omnibus longitudinaliter costatis, spiraliterque striatis; costis 12 fortibus, rotundatis; apertura rotundatâ, canali brevi.

Long. 0$\frac{4}{12}$. Lat. 0$\frac{5}{24}$. Apert. 0$\frac{2}{12}$. Asia Minor, Sporades.

Fam. *Involutæ*. Genus MITRA, *Lam.*

Mitra phillippiana, sp. nov.

M. testâ lanceolatâ flavâ, fasciâ obscurâ albidâ; anfractibus 7 convexiusculis, lævigatis, politis, labro columellari 3-plicato.

Long. 0$\frac{5}{12}$. Lat. 0$\frac{5}{24}$. Apert. 0$\frac{3}{12}$ unc. Milo, Cerigo.

Mitra granum, sp. nov.

M. testâ lineari, lævigatâ, nigridâ, fasciâ albâ maculis nigris interruptis, anfractibus 7; apice costulato, labro interno plicis 3 fortissimis.

Long. $\frac{4}{12}$. Lat. $\frac{3}{24}$. Naxia.

Mitra littoralis, sp. nov.

M. testâ lanceolatâ, viridi-fuscâ, fasciâ albâ maculis fulvis interruptis; anfractibus 6, apice costulato, labro interno 3-plicato.

Long. $\frac{3}{12}$. Lat. $\frac{3}{24}$. Paros, &c.

Genus TORNATELLA, *Lam.*

Tornatella pusilla, sp. nov.

T. testâ ovato-globosâ, albidâ, anfractibus 4 regulariter profundeque punctato-striatis, aperturâ oblongâ.

Long. 0$\frac{2}{12}$. Lat. 0$\frac{1}{12}$ unc. Lycia, Naxia.

Tornatella globulina, sp. nov.

T. testâ albâ, globosâ, spirâ brevi, anfractibus 4 spiraliter striatis, striis numerosis, simplicibus; aperturâ pyriformi, columellâ incrassatâ.

Long. 0$\frac{1}{10}$. Serpho.

LAMELLIBRANCHIATA.

Section *Dimyaria*.

Fam. *Pyloridæ*. Genus THRACIA, *Leach.*

Thracia pholadomyoides, sp. nov.

T. testâ ventricosâ, sinuosâ, granulatâ, concentricè sulcatâ, sulcis longitudinalibus paucis (6) decussatâ; umbonibus acutis.

Long. 0$\frac{9}{12}$. Lat. 1$\frac{3}{12}$ unc. Cape Artemisium (1808).

Genus LIGULA, *Montagu.*

Ligula profundissima, sp. nov.

L. testâ oblongâ, depressâ, tenui, pellucidâ, candidâ, posticè angulatâ, anticè rotundatâ; foveâ ligamentali lanceolatâ.

Long. 0$\frac{7}{24}$. Lat. 0$\frac{1}{2}$ unc.

In the 8th Region of depth, everywhere: nearly allied to *L. boysii*.

Genus NEÆRA, *Gray.*

Neæra attenuata, Forbes in Zool. Proc. 1843.

,, *abbreviata*, Do. do. 1843.

Genus POROMYA, *Forbes.*

Testa transversa, subæquivalvis, omnino clausa, punctata seu granulata; cardo in utrâque valvulâ dente cardinali erecto, subspathuliformi, dentibus obliquis duobus ad alterum anticum.

Poromya anatinoides, sp. nov.

Testa convexa, orbicularis, subcarinata, ovata, minutè granulata, anticè truncata, posticè subtruncata.

Long. 0$\frac{5}{24}$ unc. Lat. 0$\frac{4}{12}$. Reg. VIII. Asia Minor, Cyclades.

Fam. *Conchaceæ*. Genus KELLIA, *Turton* (=BORNIA, *Philippi*).

Kellia abyssicola, sp. nov.

K. testâ minutâ, lævi, politâ, candidâ, tenui, orbiculari, convexâ, umbonibus prominentibus.

Long. $0\frac{1}{12}$. Lat. $0\frac{1}{12}$ unc. In the 8th Region of depth, everywhere.

Kellia transversa, sp. nov.

K. testâ tenuissimâ, lævi, albâ, pellucidâ, valdè inæquilaterali, transversè oblongâ, extremitatibus rotundatis.

Long. $0\frac{1}{24}$ unc. Lat. $0\frac{3}{24}$. Crete (119 f.) [Capt. Graves and Lieut. Spratt]. Morea.

Kellia ferruginosa, sp. nov.

K. testâ orbiculari, subinæquilaterali, inflatâ, internè purpureâ, externè ferruginosâ.

Long. $0\frac{1}{12}$. With the last.

Genus ASTARTE, *Sowerby*.

Astarte pusilla, sp. nov.

A. testâ minutâ, triangulari, concentricè striatâ, margine interno denticulato.

Long. $0\frac{1}{12}$. Naxos. (Mr. Hoskyn.)

Fam. *Arcaceæ*. Genus NUCULA, *Lamarck*.

Nucula ægeensis, sp. nov.

N. testâ ovatâ, subdepressâ, lævi, inæquilaterali, anticè rotundatâ, posticè angulatâ, marginibus internis lævibus.

Long. $0\frac{1}{12}$. Lat. $0\frac{2}{12}$. Macri (180 f.), Crete (119 f.).

Section *Monomyaria*.

Fam. *Pectinidæ*. Genus PECTEN, *Brugière*.

Pecten fenestratus, sp. nov.

P. testâ minutâ (æquivalvi), orbiculari, costis (5) longitudinalibus, striis (10—15) transversis, interstitiis minutissimè longitudinaliter striatis; auriculis æqualibus, magnis, longitudinaliter striatis.

Lat. $0\frac{2}{12}$. Region VIII. Cyclades, Asia Minor.

Pecten concentricus, sp. nov.

P. testâ minutâ (æquivalvi) orbiculari, concentricè striatâ; auriculis inæqualibus transversè radiato-costatis.

Lat. $0\frac{2}{12}$. With the last.

Pecten hoskynsi, sp. nov.

P. testâ minutâ (æquivalvi), orbiculari, albâ, pellucidâ, costis longitudinalibus distantibus squamosis, squamis vesiculosis.

Lat. $0\frac{2}{12}$. Reg. VIII. Asia Minor.

Genus LIMA, *Brug*.

Lima (*Limatula*) *elongata*, sp. nov.

L. testâ æquilaterali pellucidâ, elongatâ, fragilissimâ, valdè tumidâ, clausâ, longitudinaliter costato-striatâ; costis lævibus, auriculis æqualibus, umbonibus valdè prominentibus.

Long. $0\frac{2}{12}$. Lat. $0\frac{1}{12}$. Cyclades, Cerigo, Lycia. Reg. VIII.

Lima (*Limatula*) *cuneata*, sp. nov.

L. testâ æquilaterali, ovatâ, candidâ, fragili, convexâ, clausâ, longitudinaliter costatâ, costis crenulatis, interstitiis longitudinaliter striatis, striis lævibus; auriculis inæqualibus, umbonibus valdè prominentibus; margine frontali argutè (12) dentato.

Long. $0\frac{3}{12}$. Lat. $0\frac{2}{12}$. Cyclades.

Lima (*Limatula*) *crassa*, sp. nov.

L. testâ æquilaterali, ovatâ, albâ, crassâ, subdepressâ, clausâ, longitudinaliter costatâ, costis crenulatis, auriculis æqualibus, umbonibus prominentibus.

Long. $0\frac{3}{24}$. Lat. $0\frac{1}{12}$. Everywhere in Reg. VIII.

Order Brachiopoda.

Fam. *Terebratulidæ*. Genus Terebratula, *Brug.*

Terebratula appressa, sp. nov.

T. testâ transversè ovatâ, planiusculâ, fuscâ, punctatâ, margine frontali recto, foramine magno incompleto, sceleto è dissepimento simplicissimo dentiformi, erecto, versus foramen arcuato.

Lat. $0\frac{3}{12}$ unc. Lycia.

APPENDIX No. III.

In the tables of species of Mollusca, several, which are familiar to continental authors under other names, are there enumerated under the specific appellations by which they had originally been described by Montagu and other authors. In order to prevent mistakes I add a concordance of such Mediterranean species as are now identified with described British forms, or have received new names in consequence of their old ones having been preoccupied.

Doris coccinea, Forbes = *Doris argo* of many British authors.
Bulla truncata, Adams = *B. semisulcata*, Philippi.
Eulima subulata (Turbo, sp.), Donovan = *Melania Cambessedesii*, Payraudeau.
Eulima polita (Helix, sp.), Montagu = *Rissoa boscii*, Payraudeau.
Parthenia elegantissima (Turbo, sp.), Montagu = *Melania campanellæ*, Philippi.
Rissoa rubra (Turbo, sp.), Adams = *Rissoa fulva*, Michaud.
Rissoa reticulata (Turbo, sp.), Montagu = *Rissoa reticulata*, Philippi.
Rissoa conifera (Turbo, sp.), Montagu = *Rissoa Brugieri*, Payraudeau.
Rissoa striata (Turbo, sp.), Adams = *Rissoa minutissima*, Michaud.
Pleurotoma gracilis (Murex, sp.), Montagu = *Pleurotoma suturale*, Bronn.
Pleurotoma attenuata (Murex, sp.), Montagu = *Pleurotoma gracile*, Philippi.
Fusus muricatus (Murex, sp.), Montagu = *Fusus echinatus*, Philippi.
Ligula sicula (Amphidesma, sp.), Sowerby = *Lutraria cottardi*, Payraudeau.
Ligula boysii, Montagu = *Erycina renieri*, Bronn.
Kellia suborbicularis (Mya, sp.), Montagu = *Bornia inflata*, Philippi.
Lyonsia striata (Mya, sp.), Montagu = *Pandorina coruscans*, Philippi.
Lucina flexuosa (Venus, sp.), Montagu = *Ptychina biplicata*, Philippi.
Lucina spinifera (Venus, sp.), Montagu = *Lucina hiatelloides*, Basterot.
Venus ovata, Montagu = *Venus radiata*, Brocchi.
Venus fasciata, Montagu = *Venus Brongniarti*, Payraudeau.
Modiola marmorata, Forbes = *Modiola discors* of British authors.
Lima subauriculata, Montagu = *Lima nivea*, Risso.

P.S. Since the Report was read and the preceding papers laid before the British Association at Cork, an additional and extensive set of researches with the dredge in various parts of the Archipelago, including the shores of Crete, have been forwarded to the reporter by Captain Graves, R.N., having been obtained by that distinguished officer and the officers of Her Majesty's surveying vessel Beacon during 1843. It is no small satisfaction to be able to state, that they fully confirm the inferences and observations embodied in this Report. E. F.

Synoptical Table of British Fossil Fishes, arranged in the order of the Geological Formations. By M. Agassiz.

SILURIAN SYSTEM.

I. Placoïdes.

Ichthyodorulithes.

Onchus Murchisoni, *Ag.* P. foss. iii. p. 6. t. 1. f. 1, 2. *Murch.* Sil. Syst. p. 607. t. 4. f. 9–11. Ludlow.

Onchus tenuistriatus, *Ag.* P. foss. iii. p. 7. t. 1. f. 10. *Murch.* Sil. Syst. p. 607. t. 4. f. 57–59. Ludlow.

Species of which the family has not yet been strictly decided.

Thelodus parvidens, *Ag.* in *Murch.* Sil. Syst. p. 605. t. 4. fig. 34, 36. Ludlow.

Sclerodus pustuliferus, *Ag.* in *Murch.* Sil. Syst. p. 605. t. 4. f. 27–32, 60–62. Ludlow.

Plectrodus mirabilis, *Ag.* in *Murch.* Sil. Syst. p. 605. t. 4. f. 14–26. Ludlow.

Plectrodus pleiopristis, *Ag.* in *Murch.* Sil. Syst. p. 606. Ludlow.

Sphagodus pristodontus, *Ag.* in *Murch.* Sil. Syst. p. 605. t. 4. f. 1–3, 6. Ludlow.

Pterygotus problematicus*, *Ag.* in *Murch.* Sil. Syst. p. 605. t. 4. f. 4, 5. Ludlow.

DEVONIAN SYSTEM.

I. Placoïdes.

Ichthyodorulithes.

Onchus arcuatus, *Ag.* P. foss. iii. p. 7. t. 1. f. 3–5. *Murch.* Sil. Syst. p. 598. t. 2. f. 10, 11. Bromyard.

Onchus semistriatus, *Ag.* P. foss. iii. p. 8. t. 1. f. 9. *Murch.* Sil. Syst. p. 598. t. 2. f. 12, 13. Southstone Rock.

Parexus recurvus, *Ag.* Msc. Balruddery.

Ctenacanthus ornatus, *Ag.* P. foss. iii. p. 12. t. 2. f. 1. *Murch.* Sil. Syst. p. 597. t. 2. f. 10. Wales. Sapey.

Ptychacanthus dubius, *Ag.* P. foss. iii. p. 176. Abergavenny.

Clematius reticulatus, *Ag.* Msc. Balruddery.

Cestraciontes.

Ctenoptychius priscus, *Ag.* P. foss. iii. p. 173. Ecosse.

II. Ganoïdes.

Lépidoïdes.

Dipterus macrolepidotus, *Sedgw.* & *Murch.* Geol. Tr. t. 15. f. 1–3; t. 16. f. 2. *Ag.* P. foss. ii. p. 115. t. 2. f. 1, 4; t. 2*a*. *Id.* Rep. 1842. *Bron.* Leth. ii. p. 125. *Murch.* Sil. Syst. p. 599. D. brachypygopterus, *S.* & *M.* Geol. Tr. t. 17. f. 1–3. *Ag.* l. c. t. 2. f. 2, D. Valenciennesii, Geol. Tr. t. 16. f. 1, 3. *Ag.* l. c. t. 2. f. 3. (Catopterus analis, p. 23–27.) Caithness. Howburn Head. Pentland Firth. Widel. Banniskirk. Clythe. Liebster. Latheron Wheele. Downton Hall.

Osteolepis arenatus, *Ag.* P. foss. ii. p. 122. t. 2*d.* f. 1–4. *Id.* Rep. 1842. Esox, *Pentl.* Geol. Tr. (n. s.) ii. p. 364. O. arenaceus, *Murch.* Sil. Syst. p. 601. Gamrie.

Osteolepis macrolepidotus, *Val.* & *Pentl.* Geol. Tr. iii. p. 143. *Ag.* P. foss. ii. p. 119. t. 2*b.* f. 1–4; t. 2*c.* f. 5, 6. *Id.* Rep. 1842. *Murch.* Sil. Syst. p. 601. Caithness. Pomona. Orkney. Cromarty.

Osteolepis microlepidotus, *Val.* & *Pentl.* Geol. Trans. iii. p. 143. *Ag.* P. foss. ii. p. 121. t. 2*c.* f. 14. *Id.* Rep. 1842. *Murch.* Sil. Syst. p. 601. Caithness. Pomona. Orkney.

Osteolepis major, *Ag.* Rep. 1842, Lethen. Gamrie.

Acanthodes pusillus, *Ag.* Rep. 1842. Gordon Castle.

Diplacanthus crassispinus, *Ag.* Rep. 1842. Stromness. Orkney. Caithness.

Diplacanthus longispinus, *Ag.* Rep. 1842. Lethen Bar. Cromarty.

Diplacanthus striatulus, *Ag.* Rep. 1842. Lethen Bar.

Diplacanthus striatus, *Ag.* Rep. 1842. Cromarty.

Cheiracanthus Murchisoni, *Ag.* P. foss. ii. p. 126. t. 1*c.* f. 3, 4. *Id.* Rep. 1842. Gamrie.

Cheiracanthus minor, *Ag.* P. foss. ii. p. 127.

* I am lately persuaded that this fossil belongs to the class of the Crustaceans.

t. 1*c*. f. 5. *Id.* Rep. 1842. *Murch.* Sil. Syst. p. 601. Pomona. Stromness.

Cheiracanthus microlepidotus, *Ag.* Rep. 1842. Lethen Bar. Cromarty.

Cheirolepis Traillii, *Ag.* P. foss. ii. p. 130. t. 1*d*; t. 1*e*. f. 4. *Id.* Rep. 1842. *Murch.* Sil. Syst. p. 601. Pomona. Stromness.

Cheirolepis Uragus, *Ag.* P. foss. ii. p. 132. t. 1*e*. f. 1–3. *Id.* Rep. 1842. *Pentl.* Geol. Tr. (n. s.) ii. p. 364. no. 2. Gamrie.

Cheirolepis Cummingiæ, *Ag.* Rep. 1842. Lethen Bar. Cromarty.

Cephalaspis Lewisii, *Ag.* P. foss. ii. p. 149. t. 1*b*. f. 8. *Id.* Rep. 1842. *Murch.* Sil. Syst. p. 593. t. 2. f. 6. Whitbach.

Cephalaspis Lloydii, *Ag.* P. foss. ii. p. 150. t. 1*b*. f. 9–11. *Id.* Rep. 1842. *Murch.* Sil. Syst. p. 594. t. 2. f. 7, 9. Whitbach. The Wyle. Sutton Hill. Downton Hall. Menai Bridge. Abergavenny.

Cephalaspis Lyellii, *Ag.* P. foss. ii. p. 142. t. 1*a*. f. 1–5; t. 1*b*. f. 1–5. *Id.* Rep. 1842. *Murch.* Sil. Syst. p. 589. t. 1. f. 1, 2; t. 2. f. 1–3. Hereford. Brecknock. Whitbach. Kidderminster. Glammis.

Cephalaspis rostratus, *Ag.* P. foss. ii. p. 148. t. 1*b*. f. 6, 7. *Id.* Rep. 1842. *Murch.* Sil. Syst. p. 592. t. 2. f. 4, 5. Whitbach.

Pterichthys cancriformis, *Ag.* Rep. 1842. Orkney.

Pterichthys cornutus, *Ag.* Rep. 1842. Lethen Bar.

Pterichthys hydrophilus, *Ag.* Rep. 1842. Dura Den.

Pterichthys latus, *Ag.* Rep. 1842. Lethen Bar.

Pterichthys Milleri, *Ag.* Rep. 1842. Gamrie. Cromarty.

Pterichthys oblongus, *Ag.* Rep. 1842. Gamrie. Cromarty.

Pterichthys productus, *Ag.* Rep. 1842. Lethen Bar.

Pterichthys testudinarius, *Ag.* Rep. 1842. Cromarty.

Coccosteus cuspidatus, *Ag.* Rep. 1842. Cromarty. Gamrie.

Coccosteus latus (v. decipiens), *Ag.* Rep. 1842. Caithness. Orkney.

Coccosteus oblongus, *Ag.* Rep. 1842. Lethen Bar.

Chelonichthys Asmusii, *Ag.* Msc. Elgin. (Riga).

Chelonichthys minor, *Ag.* Msc. Elgin. (Riga.)

Sauroïdes.

Diplopterus affinis, *Ag.* Rep. 1842. Gamrie.

Diplopterus borealis, *Ag.* Rep. 1842. Orkney. Stromness.

Diplopterus macrocephalus, *Ag.* Rep. 1842. Lethen Bar. (Printschka.)

Platygnathus paucidens, *Ag.* Rep. 1842. Caithness.

Platygnathus Jamesoni, *Ag.* Rep. 1842. Dura Den.

Platygnathus minor, *Ag.* Rep. 1842. Dura Den.

Dendrodus latus, *Ow.* *Ag.* Rep. 1842. Murrayshire.

Dendrodus strigatus, *Ow.* *Ag.* Rep. 1842. Murrayshire. (Riga.)

Dendrodus sigmoideus, *Ow.* *Ag.* Rep. 1842. Murrayshire.

Lamnodus biporcatus, *Ag.* Dendrodus biporcatus, *Ow.* *Ag.* Rep. 1842. Murrayshire. (Riga.)

Lamnodus Panderi, *Ag.* Dendrodus compressus (s. hastatus), *Ow.* *Ag.* Rep. 1842. Murrayshire. (Riga.)

Cricodus incurvus, *Ag.* Dendrodus incurvus, *Ow.* *Ag.* Rep. 1842. Murrayshire. (Riga.)

Megalichthys priscus, *Ag.* Msc. Orkney.

Cœlacanthes.

Holoptychius giganteus, *Ag.* Rep. 1842. (Cœlacanthus s. Gyrolepis giganteus.) Glammis. Gamrie. Clashbennie.

Holoptychius Flemingii, *Ag.* Rep. 1842. Dura Den.

Holoptychius nobilissimus, *Ag.* Rep. 1842. *Murch.* Sil. Syst. p. 599. t. 2 *bis*. f. 1–4, 8, 9? Clashbennie. (Printschka.)

Holoptychius Andersoni, *Ag.* Msc. Dura Den.

Holoptychius Murchisoni, *Ag.* Msc. Clashbennie.

Glyptosteus favosus, *Ag.* Msc. Elgin. (Printschka.)

Glyptosteus reticulatus, *Ag.* Msc. Clashbennie. Elgin. (Printschka.)

Phyllolepis concentricus, *Ag.* Msc. Clashbennie.

Glyptolepis elegans, *Ag.* Rep. 1842. Gamrie.

Glyptolepis leptopterus, *Ag.* Rep. 1842. Lethen Bar.

CARBONIFEROUS SYSTEM.

I. Placoïdes.

Ichthyodorulithes.

Onchus sulcatus, *Ag.* P. foss. iii. p. 8. t. 1. f. 6. Ichthyodorulithes Bristoliensis, *Buckl.* & *De la B.* (Msc.) Black Rock, Bristol.

Onchus hamatus, *Ag.* P. foss. iii. p. 9. t. 1. f. 7, 8. Blackrock.

Onchus rectus, *Ag.* P. foss. iii. p. 177. Armagh.

Onchus plicatus, *Ag.* P. foss. iii. p. 177. Armagh.
Onchus falcatus, *Ag.* P. foss. iii. p. 177. Armagh.
Onchus subulatus, *Ag.* P. foss. iii. p. 177. Rhuabon.
Ctenacanthus major, *Ag.* P. foss. iii. p. 10. t. 4. Bristol.
Ctenacanthus tenuistriatus, *Ag.* P. foss. iii. p. 11. t. 3. f. 7–11. Bristol. Gorstley Rough.
Ctenacanthus brevis, *Ag.* P. foss. iii. p. 11. t. 2. f. 2. Ichthyodorulithes brevis, *Buckl. & De la B.* (Msc.) Bristol. Armagh.
Ctenacanthus heterogyrus, *Ag.* P. foss. iii. p. 177. Armagh.
Ctenacanthus arcuatus, *Ag.* P. foss. iii. p. 177. Armagh.
Ctenacanthus crenulatus, *Ag.* P. foss. iii. p. 177. Armagh.
Ptychacanthus sublævis, *Ag.* P. foss. iii. p. 23. t. 5. f. 1–3. Burdie House.
Sphenacanthus serrulatus, *Ag.* P. foss. iii. p. 24. t. 1. f. 11–13. Burdie House.
Asteroptychius ornatus, *Ag.* P. foss. iii. p. 176. Armagh.
Asteroptychius Portlockii, *Ag.* P. foss. iii. p. 176. Ireland.
Physonemus subteres, *Ag.* P. foss. iii. p. 176. Armagh.
Gyracanthus formosus, *Ag.* P. foss. iii. p. 17. t. 5. f. 4–8. *Hibb.* Tr. Ed. Roy. Soc. xiii. *Sow.* Zool. Journ. ii. t. 8. Burdie House. Dudley. Newcastle. Rhuabon. Sunderland. Alnwick. Burnt Island.
Gyracanthus tuberculatus, *Ag.* P. foss. iii. p. 19. t. 1*a*. f. 1–7. Sunderland.
Gyracanthus Alnvicensis, *Ag.* P. foss. iii. p. 19. t. 1*a*. f. 8. Ichthyodorulithes Alnvicensis, *Buckl. & De la B.* (Msc.) Alnwick Castle.
Gyracanthus ornatus, *Ag.* P. foss. iii. p. 177. North Wales.
Oracanthus Milleri, *Ag.* P. foss. iii. p. 13. t. 3. f. 1–4. Ichthyodorulithes curvicostatus, *Buckl. & De la B.* (Msc.) Bristol.
Oracanthus minor, *Ag.* P. foss. iii. p. 16. t. 3. f. 5, 6. Bristol. Armagh.
Oracanthus pustulosus, *Ag.* P. foss. iii. p. 15. t. 2. f. 3, 4. Bristol.
Oracanthus confluens, *Ag.* P. foss. iii. p. 177. Armagh.
Lepracanthus Colei, *Egert.* *Ag.* P. foss. iii. p. 177. Rhuabon.
Leptacanthus priscus, *Ag.* P. foss. iii. p. 176. Armagh.
Tristychius arcuatus, *Ag.* P. foss. iii. p. 22. t. 1*a*. f. 9–11. Greenside near Glasgow.
Cladacanthus paradoxus, *Ag.* P. foss. iii. p. 176. Armagh.
Cricacanthus Jonesii, *Ag.* P. foss. iii. p. 176. Armagh.
Orthacanthus cylindricus, *Ag.* P. foss. iii. p. 330. t. 45. f. 7–9. Leeds.
Pleuracanthus lævissimus, *Ag.* P. foss. iii. p. 66. t. 45. f. 4, 5. Dudley.
Pleuracanthus planus, *Ag.* P. foss. iii. p. 177. Leeds.
Pleuracanthus cylindricus, *Egert.* Msc. North Wales.

Cestraciontes.

Orodus cinctus, *Ag.* P. foss. iii. p. 96. t. 11. f. 1–4. Bristol.
Orodus ramosus, *Ag.* P. foss. iii. p. 97. t. 11. f. 5–9. Bristol.
Helodus simplex, *Ag.* P. foss. iii. p. 104. t. 19. f. 8–10. N. Stafford. Coalbrook Dale.
Helodus lævissimus, *Ag.* P. foss. iii. p. 104. t. 14. f. 1–15. (Psammodus lævissimus.) Bristol.
Helodus subteres, *Ag.* P. foss. iii. p. 105. t. 12. f. 3, 4. (Psammodus subteres.) Bristol.
Helodus gibberulus, *Ag.* P. foss. iii. p. 106. t. 12. f. 1, 2. (Psammodus gibberulus.) Bristol.
Helodus turgidus, *Ag.* P. foss. iii. p. 106. t. 15. f. 1–12. (Psammodus turgidus.) Bristol. Armagh.
Helodus mitratus, *Ag.* P. foss. iii. p. 173. Carluke.
Helodus didymus, *Ag.* P. foss. iii. p. 173. Armagh.
Helodus mammillaris, *Ag.* P. foss. iii. p. 173. Armagh.
Helodus planus, *Ag.* P. foss. iii. p. 173. Armagh.
Chomatodus cinctus, *Ag.* P. foss. iii. p. 107. t. 15. f. 13–21. (Psammodus cinctus.) Bristol.
Chomatodus linearis, *Ag.* P. foss. iii. p. 108. t. 12. f. 5–13. (Psammodus linearis.) Bristol.
Chomatodus truncatus, *Ag.* P. foss. iii. p. 174. Armagh.
Cochliodus contortus, *Ag.* P. foss. iii. p. 115. t. 19. f. 14; t. 14. f. 16–33. (Psammodus contortus.) Bristol. Armagh. Clifton.
Cochliodus magnus, *Ag.* P. foss. iii. p. 174. Armagh.
Cochliodus oblongus, *Ag.* P. foss. iii. p. 174. Armagh.
Cochliodus acutus, *Ag.* P. foss. iii. p. 174. Armagh.
Cochliodus striatus, *Ag.* P. foss. iii. p. 174. Armagh.
Psammodus rugosus, *Ag.* P. foss. iii. p. 111. t. 12. f. 14–18; t. 19. f. 15. *Con. & Ph.* Geol. vi. p. 356. Dens tritor rugosus, *Mill.* Cat. Mus. Brist. Bristol. Armagh. Easky. (Eifel.)
Psammodus porosus, *Ag.* P. foss. iii. p. 112. t. 13. f. 1–18. Bristol. Armagh.
Psammodus cornutus, *Ag.* P. foss. iii. p. 174. Armagh.
Psammodus obtusus, *Ag.* Msc. Stafford.
Pœcilodus Jonesii, *Ag.* P. foss. iii. p. 174. Armagh.
Pœcilodus parallelus, *Ag.* P. foss. iii. p. 174. Armagh.

Pœcilodus transversus, *Ag.* P. foss. iii. p. 174. Armagh.
Pœcilodus obliquus, *Ag.* P. foss. iii. p. 174. Armagh. Carluke.
Pœcilodus sublævis, *Ag.* P. foss. iii. p. 174. Armagh.
Pœcilodus angustus, *Ag.* P. foss. iii. p. 174. Carluke.
Pleurodus affinis, *Ag.* P. foss. iii. p. 174. Rhuabon. Carluke.
Pleurodus Rankinei, *Ag.* P. foss. iii. p. 174. Carluke.
Ctenoptychius apicalis, *Ag.* P. foss. iii. p. 99. t. 19. f. 1, 1*a*. Stafford. Manchester.
Ctenoptychius pectinatus, *Ag.* P. foss. iii. p. 100. t. 19. f. 2–4. Burdie House. Manchester.
Ctenoptychius denticulatus, *Ag.* P. foss. iii. p. 101. t. 19. f. 5–7. Burdie House. Manchester.
Ctenoptychius cuspidatus, *Ag.* P. foss. iii. p. 173. Glasgow.
Ctenoptychius dentatus, *Ag.* P. foss. iii. p. 173. Armagh.
Ctenoptychius serratus, *Ag.* P. foss. iii. p. 173. Armagh.
Ctenoptychius macrodus, *Ag.* P. foss. iii. p. 173. Armagh.
Ctenoptychius crenatus, *Ag.* P. foss. iii. p. 173. Carluke.
Ctenodus cristatus, *Ag.* P. foss. iii. p. 137. t. 19. f. 16. Tong near Leeds.
Ctenodus Robertsoni, *Ag.* P. foss. iii. p. 174. Burdie House.
Ctenodus alatus, *Ag.* P. foss. iii. p. 174. Ardwick.
Ctenodus Murchisoni, *Ag.* Msc. Botwood.
Petalodus acuminatus, *Ag.* P. foss. iii. p. 174. Chematodus acuminatus, *Ag.* l. c. p. 108. t. 19. f. 11–13. Durham. Yorkshire. Glasgow.
Petalodus Hastingsiæ, *Ow.* *Ag.* P. foss. iii. p. 174. Armagh.
Petalodus psittacinus, *Ag.* P. foss. iii. p. 174. Armagh.
Petalodus lævissimus, *Ag.* P. foss. iii. p. 174. Armagh.
Petalodus rectus, *Ag.* P. foss. iii. p. 174. Armagh.
Petalodus radicans, *Ag.* P. foss. iii. p. 174. Armagh.
Petalodus marginalis, *Ag.* P. foss. iii. p. 174. Armagh.
Petalodus sagittatus, *Ag.* P. foss. iii. p. 174. Armagh.

Hybodontes.

Cladodus mirabilis, *Ag.* P. foss. iii. p. 197. t. 22*b*. f. 9–13. Bristol. Armagh.
Cladodus striatus, *Ag.* P. foss. iii. p. 197. t. 22*b*. f. 14–17. Armagh.
Cladodus marginatus, *Ag.* P. foss. iii. p. 198. t. 22*b*. f. 18–20. Armagh.
Cladodus Milleri, *Ag.* P. foss. iii. p. 199. t. 22*b*. f. 22, 23. Bristol.
Cladodus conicus, *Ag.* P. foss. iii. p. 199. t. 22*b*. f. 24. Bristol.
Cladodus acutus, *Ag.* P. foss. iii. p. 199. t. 22*b*. f. 21. Laughgal.
Cladodus Hibberti, *Ag.* P. foss. iii. p. 200. t. 22*b*. f. 25. Burdie House.
Cladodus parvus, *Ag.* P. foss. iii. p. 200. t. 22*b*. f. 26, 27. Burdie House.
Diplodus gibbosus, *Ag.* P. foss. iii. p. 204. t. 22*b*. f. 1–5. Edinburgh. Carluke. Derbyshire. North Stafford.
Diplodus minutus, *Ag.* P. foss. iii. p. 205. t. 22*b*. f. 6–8. Burdie House.

Squalides.

Carcharopsis prototypus, *Ag.* P. foss. iii. p. 313. Yorkshire. Armagh.

II. Ganoïdes.

Lépidoïdes.

Acanthodes sulcatus, *Ag.* P. foss. ii. p. 125. t. 1*c*. f. 1, 2. New Haven.
Amblypterus nemopterus, *Ag.* P. foss. ii. p. 107. t. 4*b*. f. 1, 2. Wardie. New Haven. Inchkeith.
Amblypterus punctatus, *Ag.* P. foss. ii. p. 109. t. 4*c*. f. 3–8. New Haven.
Amblypterus striatus, *Ag.* P. foss. ii. p. 111. t. 4*b*. f. 3–6. Rep. of Brit. Assoc. for 1834, p. 76. New Haven.
Palæoniscus carinatus, *Ag.* P. foss. ii. p. 104. t. 4*c*. f. 1, 2. Rep. of Brit. Assoc. for 1834, p. 76. New Haven.
Palæoniscus Egertoni, *Ag.* Msc. Staffordshire.
Palæoniscus Monensis, *Egert.* Msc. Anglesea.
Palæoniscus ornatissimus, *Ag.* P. foss. ii. p. 92. t. 10*a*. f. 5–8. Burnt Island. Burdie House.
Palæoniscus Robisoni, *Hibb.* Tr. Edinb. Roy. Soc. xiii. t. 6. f. 7; t. 7. f. 3. *Ag.* P. foss. ii. p. 88. t. 10*a*. f. 1, 2. Burdie House.
Palæoniscus striolatus, *Ag.* P. foss. ii. p. 91. t. 10*a*. f. 3, 4. *Hibb.* Tr. Edinb. Roy. Soc. xiii. t. 6. f. 6; t. 7. f. 1. Burdie House.
Eurynotus crenatus, *Ag.* P. foss. ii. p. 154. t. 14*a*, 14*b*. Burdie House.
Eurynotus fimbriatus, *Ag.* P. foss. ii. p. 157. t. 14*c*. f. 1–3. New Haven.
Platysomus parvulus, *Ag.* Msc. Leeds.
Plectrolepis rugosus, *Ag.* Msc. Carluke.

Sauroïdes.

Megalichthys Hibberti, *Ag.* P. foss. ii. p. 87. t. 63, 64. *Bron.* Leth. ii. p. 129. t. 10. f. 8. Burdie House. Newcastle. North Stafford. Leeds. Glasgow. Carluke.

Megalichthys maxillaris, *Ag.* Msc. Leeds.
Diplopterus carbonarius, *Ag.* Msc. Leeds.
Diplopterus Robertsoni, *Ag.* Msc. Burdie House.
Pygopterus Bucklandi, *Ag.* P. foss. ii. part 2. p. 77. Burdie House.
Pygopterus Jamesoni, *Ag.* P. foss. ii. part 2. p. 78. Burdie House.
Pygopterus Greenockii, *Ag.* P. foss. ii. part 2. p. 78. New Haven.
Acrolepis acutirostris, *Ag.* Msc. Carluke.
Orognathus conidens, *Ag.* Msc. Carluke.
Graptolepis ornatus, *Ag.* Msc. Carluke.
Pododus capitatus, *Ag.* Msc. Carluke.

Cœlacanthes.

Cœlacanthus Phillipsii, *Ag.* P. foss. ii. Halifax.
Cœlacanthus lepturus, *Ag.* Msc. Leeds. Manchester.
Holoptychius Hibberti, *Ag.* P. foss. ii. (Rhizodus, *Ow.*) Burdie House.
Holoptychius sauroides, *Ag.* Msc. Edinburgh. Leeds.
Holoptychius falcatus, *Ag.* Msc. Greenside near Glasgow.
Holoptychius Portlockii, *Ag.* Msc. Ireland.
Holoptychius Garneri, *Murch.* Sil. Syst. p. 474. Lanesfield.
Holoptychius granulatus, *Ag.* Msc. Rhuabon. North Stafford.
Holoptychius striatus, *Ag.* Msc. (Megalichthys.) (Millst. Gr.) Edinburgh.
Holoptychius minor, *Ag.* Msc. Leeds. North Stafford.
Hoplopygus Binneyi, *Ag.* Msc. Manchester.
Uronemus lobatus, *Ag.* Msc. Burdie House.
Phyllolepis tenuissimus, *Ag.* Msc. Burdie House.

PERMIAN SYSTEM.

I. Placoïdes.

Ichthyodorulithes.

Gyropristis obliquus, *Ag.* P. foss. iii. p. 177. (C. magn.) Belfast.

II. Ganoïdes.

Lépidoïdes.

Palæoniscus comtus, *Ag.* P. foss. ii. p. 97. t. 10*b*. f. 1–3. Palæothrissum magnum, Geol. Tr. (S. 2.) iii. t. 8. f. 1, 2. Palæothr. macrocephalum, Ibid. t. 9. f. 2. (C. magn.) East Thickley. Midderidge. Darlington. Clar. Railw. West Bolden. Houghton. Whitley. Rushyford.
Palæoniscus elegans, *Ag.* P. foss. ii. p. 82, 95. t. 10*b*. f. 4, 5. *Sedgw.* Geol. Trans. (S. 2.) iii. t. 9. f. 1. (Palæothrissum.) (C. magn.) East Thickley. Midderidge. Darlington, &c.
Palæoniscus glaphyrus, *Ag.* P. foss. ii. p. 98. t. 10*c*. f. 1, 2. (C. magn.) Midderidge. East Thickley. Darlington. Clar. Railway. West Bolden. Houghton. Whitley and Rushyford. Ferry Hill.
Palæoniscus longissimus, *Ag.* P. foss. ii. p. 100. t. 10*c*. f. 4. (C. magn.) East Thickley. Midderidge. Darlington. Clar. Railway. West Bolden. Houghton, &c.
Palæoniscus macrophthalmus, *Ag.* P. foss. ii. p. 99. t. 10*c*. f. 3. (C. magn.) East Thickley. Midderidge. Darlington. Clar. Railway. West Bolden. &c.
Platysomus macrurus, *Ag.* P. foss. ii. p. 170. t. 18. f. 1, 2. *Sedgw.* Geol. Tr. (S. 2.) iii. t. 12. f. 1, 2. Uropteryx undulatus, *Ag.* Msc. *Walch.* Geol. p. 270. East Thickley.
Platysomus parvus, *Ag.* P. foss. ii. p. 170. t. 18. f. 3. *Clanny,* Ann. of Phil. vi. p. 115 (Chætodon). *Winch.* Geol. Tr. iv. t. 2. (C. magn.) Low Pallion, Northumb.
Platysomus striatus, *Ag.* P. foss. ii. p. 168. t. 17. f. 1–4. Uropteryx striatus, *Ag.* Msc. *Walchn.* Geol. p. 720. *Sedgw.* Geol. Tr. (S. 2.) iii. t. 12. f. 3, 4. (C. magn.) Ferry Hill. Whitley. Durham.

Sauroïdes.

Acrolepis Sedgwickii, *Ag.* P. foss. ii. p. 11. t. 52. Geol. Tr. (S. 2.) iii. t. 8. f. 3. *Bron.* Leth. ii. p. 120. t. 10. f. 6. (C. magn.) East Thickley. Ferry Hill.
Pygopterus mandibularis, *Ag.* P. foss. ii. p. 10. t. 53, 53*a*. Geol. Tr. (S. 2.) iii. t. 10. f. 1–3. Nemopteryx mandibularis, s. Sauropsis scoticus, *Ag.* (Anc. Cat.) P. scoticus, *Ag.* *Bron.* Leth. ii. p. 128. (C. magn.) East Thickley. Ferry Hill.
Pygopterus sculptus, *Ag.* P. foss. ii. part 2. p. 77. (C. magn.)

Cœlacanthes.

Cœlacanthus granulatus, *Ag.* P. foss. ii. t. 62. (C. magn.) Durham. Ferry Hill. East Thickley.

TRIASIC SYSTEM.

I. Placoïdes.

Ichthyodorulithes.

Hybodus minor, *Ag.* P. foss. iii. p. 48. t. 8*b.* f. 2, 3. (p. 183. t. 23. f. 21–24.) (Boneb.) Bristol. Austcliff. Westbury. Pyrton-on-Severn.

Nemacanthus monilifer, *Ag.* P. foss. iii. p. 26. t. 7. f. 10–15. (Boneb.) Bristol. Westbury.

Nemacanthus filifer, *Ag.* P. foss. iii. p. 26. t. 7. f. 9. (Boneb.) Bristol. Austcliff. Westbury.

Leiacanthus (spec. ined.), *Ag.* Msc. (Boneb.) Austcliff.

Cestraciontes.

Acrodus minimus, *Ag.* P. foss. iii. p. 145. t. 22. f. 6–12. (Boneb.) Austcliff. Lyme Regis. Axmouth.

Ceratodus latissimus, *Ag.* P. foss. iii. p. 131. t. 20. f. 8, 9. (Boneb.) Austcliff.

Ceratodus curvus, *Ag.* P. foss. iii. p. 131. t. 20. f. 10. (Boneb.) Austcliff.

Ceratodus planus, *Ag.* P. foss. iii. p. 132. t. 20. f. 6, 7. (Boneb.) Austcliff.

Ceratodus parvus, *Ag.* P. foss. iii. p. 132. t. 20. f. 1. (Boneb.) Austcliff.

Ceratodus emarginatus. *Ag.* P. foss. iii. p. 133. t. 20. f. 11–13. (Boneb.) Austcliff.

Ceratodus gibbus, *Ag.* P. foss. iii. p. 133. t. 20. f. 14, 15. (Boneb.) Austcliff.

Ceratodus dædaleus, *Ag.* P. foss. iii. p. 133. t. 20. f. 16. (Boneb.) Austcliff.

Ceratodus altus, *Ag.* P. foss. iii. p. 134. t. 18. f. 1, 2; t. 20. f. 2–5. (Boneb.) Austcliff.

Ceratodus obtusus, *Ag.* P. foss. iii. p. 134. t. 19. f. 20, 21. (Boneb.) Austcliff.

Ceratodus disauris, *Ag.* P. foss. iii. p. 135. t. 19. f. 19. (C. bicornis, *Feuil.* p. 112.) (Boneb.) Austcliff.

Hybodontes.

Hybodus minor, *Ag.* P. foss. iii. (p. 48. t. 8*b.* f. 2, 3.) p. 183. t. 23. f. 21–24. (Boneb.) Bristol. Austcliff. Westbury. Pyrton-on-Severn.

II. Ganoïdes.

Lépidoïdes.

Gyrolepis Albertii, *Ag.* P. foss. ii. p. 173. t. 19. *Bron.* Leth. ii. p. 185. t. 13. f. 8. (Gr. big.) Wickwarr near Bristol. (Boneb.) Axmouth. (Mschk. Friderichshall. Rottweil. Baireuth. Rietheim. Biberfeld. Rottenmünster. Breslau. Vosges. Meurthe.)

Gyrolepis maximus, *Ag.* P. foss. ii. p. 175. t. 19. (Gr. big.) Wickwarr. (Mschk. Friderichshall. Rottenmünster. Biberfeld. Baireuth. Breslau. Lunéville.)

Gyrolepis tenuistriatus, *Ag.* P. foss. ii. p. 174. t. 19. *Alb.* Monogr. p. 120. (Gr. big.) Wickwarr. (Boneb.) Axmouth. (Mschk. Rottweil. Biberfeld. Rietheim. Tubingue. Baireuth. Breslau. Lunéville.

Palæoniscus catopterus, *Ag.* P. foss. ii. (N. Red.) Roan hill.

Sauroïdes.

Saurichthys apicalis, *Ag.* P. foss. ii. p. 12. *Münst.* Beitr. i. p. 116. t. 14. f. 1, 2. *Bron.* Leth. ii. p. 185. (Boneb.) Axmouth. (Mschk. Baireuth. Laineck. Benk. Göttingen. Hildesheim. Jena.)

Saurichthys acuminatus, *Ag.* P. foss. ii. (S. conicus olim.) (Boneb.) Austcliff.

Saurichthys longidens, *Ag.* P. foss. ii. (Boneb.) Austcliff. Pyrton-on-Severn.

OOLITIC SYSTEM.

I. Placoïdes.

Ichthyodorulithes.

Leptacanthus tenuispinus, *Ag.* P. foss. iii. p. 27. t. 1*a.* f. 12, 13. (Lias.) Lyme Regis.

Leptacanthus semistriatus, *Ag.* P. foss. iii. p. 28. t. 7. f. 3–8. Ichthyodorulithes Stonesfieldensis, *Buckl. & De la B.* (Gr. ool.) Stonesfield.

Leptacanthus serratus, *Ag.* P. foss. iii. p. 29. t. 7. f. 1, 2. (? Gr. ool.) ? Stonesfield.

Nemacanthus brevispinus, *Ag.* Msc. (Gr. ool.) Stonesfield.

Myriacanthus paradoxus, *Ag.* P. foss. iii. p. 38. t. 6. Geol. Tr. (2nd series) i. p. 65. f. 1, 2. (Lias.) Lyme Regis.

Myriacanthus retrorsus, *Ag.* P. foss. iii. p. 39. t. 8*a.* f. 14, 15. (Lias.) Lyme Regis.

Myriacanthus granulatus, *Ag.* P. foss. iii. p. 40. t. 8*a.* f. 16. (Lias.) Lyme Regis.

Asteracanthus Stutchburyi, *Ag.* P. foss. iii. p. 177. (Lias.) Charmouth.
Asteracanthus acutus, *Ag.* P. foss. iii. p. 23. t. 8*a*. f. 1–3. (Up. Cornbr.) Castle Miles.
Asteracanthus minor, *Ag.* P. foss. iii. p. 33. t. 8*a*. f. 4–6. (Ool.)
Asteracanthus semisulcatus, *Ag.* P. foss. iii. p. 34. t. 8*a*. f. 7–10. Ichthyodorulithes Purbecensis, *B. & De la B.* (Ool.) Stonesfield. (Purb.) Swanwick.
Asteracanthus ornatissimus, *Ag.* P. foss. iii. p. 31. t. 8. Ichthyodorulithes Heddingtonensis, *B. & De la B.* A. ornatissimus, *Bron.* Leth. ii. t. 8. *Gressly* in *Leonh. u. Br.* N. Jahrb. 1836. p. 663. *Fitt.* Geol. Trans. iv. p. 367. (Kimm.) Shotover. Heddington. (Portl. Soleure.)
Hybodus crassispinus, *Ag.* P. foss. iii. p. 48. t. 8*b*. f. 7. (Lias.) Lyme Regis.
Hybodus reticulatus, *Ag.* P. foss. iii. p. 50. t. 9. f. 1–9. (H. incurvus et curtus, *Ag.*) *Con. & Ph.* Geol. vi. p. 267. Geol. Tr. (2nd series) i. t. 4. f. 7–10; t. 5. f. 3, 4. Ichthyodorulithes Dorsetiensis, *B. & De la B.* *Buckl.* Geol. Miner. t. 27*d*. f. *c*. 1–4. Geol. Trans. (n. s.) iii. t. 9. (Lias.) Lyme Regis. Neston. Keynsham. (Würtemberg.)
Hybodus formosus, *Ag.* P. foss. iii. p. 51. t. 9. f. 10, 11. (H. speciosus, ornatus, grossispinus.) (Lias.) Lyme Regis.
Hybodus ensatus, *Ag.* P. foss. iii. p. 51. t. 9. f. 12. (H. crassus olim.) (Lias.) Lyme Regis.
Hybodus marginalis, *Ag.* P. foss. iii. p. 43. t. 10. f. 18–21. (Ool.) Stonesfield. Tilgate. (Lias.) Keynsham.
Hybodus crassus, *Ag.* P. foss. iii. p. 47. t. 10. f. 23. (Ool. inf.) Rodmore Pits. (Ool. ferr. Wasseralfingen.)
Hybodus apicalis, *Ag.* P. foss. iii. p. 43. t. 10. f. 22; p. 195. t. 23. f. 16, 20. (Ool.) Stonesfield. Tilgate. (Lias.) Lyme Regis. (Keup. Hildesheim).
Hybodus dorsalis, *Ag.* P. foss. iii. p. 42. t. 10. f. 1. (Ool.) Stonesfield. Tilgate. ? Bath. Hastings.
Hybodus leptodus, *Ag.* P. foss. iii. p. 44. t. 10. f. 2, 3. (? Ool.) ? Shotover Hill.
Hybodus striatulus, *Ag.* P. foss. iii. p. 44. t. 8*b*. f. 1, 1*a*. *Mant.* Tilg. t. 10. f. 4, 6. (Weald.) Hastings.
Hybodus acutus, *Ag.* P. foss. iii. p. 45. t. 10. f. 4–6. (Kimm.) Shotover.
Hybodus strictus, *Ag.* P. foss. iii. p. 45. t. 10. f. 7–9. Portland. Purbeck.
Hybodus subcarinatus, *Ag.* P. foss. iii. p. 46. t. 10. f. 10–12. Geol. Tr. (n. s.) ii. t. 6. (Weald.) Tilgate.
Pristacanthus Securis, *Ag.* P. foss. iii. p. 35. t. 8*a*. f. 11–13. (Ool.) Stonesfield. (Caen.)

Cestraciontes.

Acrodus nobilis, *Ag.* P. foss. iii. p. 140. t. 21. *Con. & Ph.* Geol. i. p. 267. Geol. Tr. (n. s.) i. t. 4. f. 6. (Lias.) Lyme Regis.
Acrodus latus, *Ag.* P. foss. iii. p. 144. (Lias.) Lyme Regis.
Acrodus gibberulus, *Ag.* P. foss. iii. p. 144. t. 22. f. 1, 3. (Lias.) Lyme Regis.
Acrodus undulatus, *Ag.* P. foss. iii. p. 144. (Lias.) Lyme Regis.
Acrodus Anningiæ, *Ag.* P. foss. iii. p. 174. t. 22. f. 4. (Lias.) Lyme Regis.
Acrodus leiopleurus, *Ag.* P. foss. iii. p. 145. t. 22. f. 5. (Ool.) Bath. ? Stonesfield.
Acrodus Hirudo, *Ag.* P. foss. iii. p. 148. t. 22. f. 27. (Weald.) Tilgate.
Acrodus leiodus, *Egert.* Msc. (Ool.) Stonesfield.
Ceratodus Phillipsii, *Ag.* P. foss. iii. p. 135. t. 19. f. 17. (Ool.) Stonesfield.
Strophodus magnus, *Ag.* P. foss. iii. p. 126. t. 18. f. 11–15. (Psammodus magnus, *Ag.* Msc.). *Luid.* t. 16. f. 1448, 1445, 1442. *C. Prév.* Ann. Sc. nat. iv. Nos. 10–14. (Gr. ool.) Stonesfield. Dundry. (C. jur. Ranville.)
Strophodus tenuis, *Ag.* P. foss. iii. p. 127. t. 18. f. 16–25. (Gr. ool.) Stonesfield. Dundry.
Strophodus radiato-punctatus, *Ag.* P. foss. iii. p. 128. t. 18. f. 27. (Kellow. R.)
Strophodus favosus, *Ag.* P. foss. iii. p. 175. (Gr. ool.) Stonesfield.
Strophodus reticulatus, *Ag.* P. foss. iii. p. 123. t. 17. (Psammodus reticulatus.) (Kimm.) Shotover.
Strophodus subreticulatus, *Ag.* P. foss. iii. p. 125. t. 18. f. 5–10. (Ool. inf.) Dundry. (C. à Tort. Soleure.)

Hybodontes.

Hybodus reticulatus, *Ag.* P. foss. iii. p. 180. t. 24. f. 26; t. 22*a*. f. 22, 23. (Lias.) Lyme Regis. Neston. Keynsham.
Hybodus pyramidalis, *Ag.* P. foss. iii. p. 182. t. 22*a*. f. 20, 21. (H. pachyprion et Johnsoni, *Ag.* Msc.) (Lias.) Lyme Regis.
Hybodus medius, *Ag.* P. foss. iii. p. 184. t. 24. f. 25. (H. homoprion, *Ag.* Msc.) (Lias.) Lyme Regis.
Hybodus grossiconus, *Ag.* P. foss. iii. p. 184. t. 23. f. 25–41. (Gr. ool.) Stonesfield. (Weald.) Tilgate. (Ool. Caen.)
Hybodus polyprion, *Ag.* P. foss. iii. p. 185. t. 23. f. 1–15. (Ool.) Stonesfield ? Dundry. (Caen.)
Hybodus obtusus, *Ag.* P. foss. iii. p. 186. t. 23. f. 43, 44. (Ool.) Malton ? (Caen.)
Hybodus raricostatus, *Ag.* P. foss. iii. p. 187. t. 24. f. 24. (Ool.) Stonesfield ? (Lias.) Bristol.
Hybodus dubius, *Ag.* P. foss. iii. p. 188. t. 22*a*. f. 8–10. (Purb.) Linksfield.
Hybodus undulatus, *Ag.* P. foss. iii. p. 188. t. 22*a*. f. 11. (Purb.) Linksfield.

Hybodus carinatus, *Ag.* P. foss. iii. p. 52. t. 9. f. 13, 14. (Lias.) Lyme Regis.

Sphenonchus hamatus, *Ag.* P. foss. iii. p. 202. t. 22*a*. f. 12–14. (Onchus et Leiosphen olim). *Buckl.* Min. Geol. t. 27*d*. f. 6, 7. (Lias.) Lyme Regis.

Sphenonchus elongatus, *Ag.* P. foss. iii. p. 202. t. 22*a*. f. 18, 19. (Weald.) Tilgate Forest.

Sphenonchus Martini, *Rob. Ag.* P. foss. iii. p. 203. t. 22*a*. f. 15–17. (Portl.) Linksfield.

Squalides.

Thyellina prisca, *Ag.* P. foss. iii. p. 378. t. 39. f. 1, 2. (Lias.) Lyme Regis.

Oxyrhina (Meristodon) paradoxa, *Ag.* P. foss. iii. p. 286. t. 36. f. 53–56. (Ool.) Tilgate.

Raies.

Arthropterus Rileyi, *Ag.* P. foss. iii. p. 379. (Lias.) Bristol.

Cyclarthrus macropterus, *Ag.* P. foss. iii. p. 382. t. 44. f. 1. (Lias.) Lyme Regis.

Squaloraja polyspondyla, *Ag.* P. foss. iii. p. 381. t. 42, 43. Squaloraja dolichognatha, *Riley*, Proc. Geol. Soc. 1833. Lond. and Edinb. Phil. Journ. iii. p. 369. Spinacorhinus polyspondylus, *Ag.* T. cit. et Feuill. p. 94. (Lias.) Lyme Regis.

Chimérides.

Chimæra (Ischyodon) emarginata, *Egert. Ag.* P. foss. iii. p. 345. (Ool.) Stonesfield.

Chimæra (Ischyodon) Egertoni, *Buckl.* Proc. Geol. Soc. ii. p. 206. *Ag.* P. foss. iii. p. 340. t. 40*c*. f. 1–10. (Kimm.) Shotover.

Chimæra (Ischyodon) Townsendii, *Buckl.* Proc. Geol. Soc. ii. p. 206. *Ag.* P. foss. iii. p. 343. t. 40. f. 20–22; t. 40*c*. f. 17, 18. (Portl.) Great Milton.

Chimæra (Ischyodon) Johnsonii, *Ag.* P. foss. iii. p. 344. t. 40*c*. f. 22. (Lias.) Charmouth.

Chimæra (Ganodus) Colei, *Buckl. Ag.* P. foss. iii. p. 346. t. 40. f. 8–10. (Ool.) Stonesfield.

Chimæra (Ganodus) Owenii, *Buckl. Ag.* P. foss. iii. p. 347. t. 40. f. 6, 7. (Ool.) Stonesfield.

Chimæra (Ganodus) rugulosa, *Egert.* Msc. *Ag.* P. foss. iii. p. 347. (Ool.) Stonesfield.

Chimæra (Ganodus) neglecta, *Egert.* Msc. *Ag.* P. foss. iii. p. 347. t. 40*c*. f. 11. (Ool.) Stonesfield.

Chimæra (Ganodus) curvidens, *Egert. Ag.* P. foss. iii. p. 348.

Chimæra (Psittacodon) falcata, *Egert.* Msc. *Ag.* P. foss. iii. p. 349. t. 40*c*. f. 13. (Ool.) Stonesfield.

Chimæra (Psittacodon) psittacina, *Egert.* Msc. *Ag.* P. foss. iii. p. 350. t. 40*c*. f. 12. (Ool.) Stonesfield.

II. Ganoïdes.

Lépidoïdes.

Dapedius arenatus, *Ag.* Msc. (Lias.) Lyme Regis.

Dapedius Colei, *Ag.* P. foss. ii. p. 195. t. 25*b*. f. 1–7. t. 25*c*. Dapedium politum, *Cole* (non *De la B.*) (Lias.) Lyme Regis.

Dapedius granulatus, *Ag.* P. foss. ii. p. 190. t. 25. f. 2–5, 6*a*, *b*. (Lias.) Lyme Regis.

Dapedius micans, *Ag.* Msc. (Lias.) Whitby.

Dapedius Orbis, *Ag.* P. foss. ii. p. 218. t. 25*d*. (Lias.) Barrow. Whitby.

Dapedius politus (*Leach*), *De la B.* Geol. Tr. (2nd ser.) i. t. 6. f. 1–4. *Ag.* P. foss. ii. p. 185. t. 25. f. 1, 6*c*. *Krüg.* Naturg. i. p. 219. *Holl.* Petref. p. 113. *Woodw.* p. 37. *Goldf.* ap. *Dech.* p. 419. *Bron.* Leth. ii. p. 484. (Lias.) Lyme Regis.

Dapedius punctatus, *Ag.* P. foss. ii. p. 192. t. 25*a*; t. 25. f. 6*d*, 7, 8, 9. (Lias.) Lyme Regis.

Tetragonolepis angulifer, *Ag.* P. foss. ii. p. 213. t. 23. (T. Traillii, pp. 7, 214.) (Lias.) Stratford on Avon.

Tetragonolepis confluens, *Ag.* P. foss. ii. p. 199. t. 23*a*. f. 1. (Lias.) Lyme Regis.

Tetragonolepis dorsalis, *Ag.* P. foss. ii. p. 211. t. 21. f. 1, 2; t. 21*a*. f. 1. (Lias.) Byrford.

Tetragonolepis heteroderma, *Ag.* P. foss. ii. p. 206. t. 23*e*. f. 1. (Lias.) Lyme Regis. (Boll.)

Tetragonolepis Leachii, *Ag.* P. foss. ii. p. 203. t. 23*d*, bis. (Lias.) Lyme Regis.

Tetragonolepis leiosomus, *Ag.* P. foss. ii. p. 202. t. 23*a*. f. 3. (Lias.) Lyme Regis.

Tetragonolepis mastodontus, *Ag.* P. foss. ii. p. 216. t. 23*e*. f. 3–5. Geol. Tr. (2nd series) ii. t. 6. (Weald.) Hastings.

Tetragonolepis monilifer, *Ag.* P. foss. ii. p. 212. t. 21*a*. f. 2–5. (Lias.) Banwell. Barrow.

Tetragonolepis ovalis, *Ag.* P. foss. ii. p. 209. t. 21. f. 3. (Lias.) Whitby. (Boll.)

Tetragonolepis pholidotus, *Ag.* P. foss. ii. p. 207. t. 23*e*. f. 2. (Lias.) Lyme Regis. (Boll.)

Tetragonolepis pustulatus, *Ag.* P. foss. ii. p. 201. t. 23*c*. (Lias.) Lyme Regis.

Tetragonolepis radiatus, *Ag.* P. foss. ii. p. 201. t. 23*a*. f. 2. (Lias.) Lyme Regis.

Tetragonolepis speciosus, *Ag.* P. foss. ii. p. 199. t. 23*b*. (Lias.) Lyme Regis.

Tetragonolepis striolatus, *Ag.* Msc. (Lias.) Barrow.

Centrolepis asper, *Egert.* Msc. (Lias.) Lyme Regis.

Amblyurus macrostomus, *Ag.* P. foss. ii. p. 220.

t. 25*e*. *Bron.* Leth. ii. p. 284. (Lias.) Lyme Regis. Street.

Semionotus rhombifer, *Ag.* P. foss. ii. p. 228. t. 26*a*. (Lias.) Lyme Regis.

Lepidotus fimbriatus, *Ag.* P. foss. ii. p. 247. t. 33*b*. (Dapedius fimbriatus, *Ag.* Feuill. p. 9.) (Lias.) Lyme Regis. (C. jur. Tyrol. ? Keup. Coburg.)

Lepidotus Fittoni, *Ag.* P. foss. ii. p. 265. t. 30. f. 4–6 (non *Mant.*); t. 30*a*, 30*b*. (Weald.) Tilgate.

Lepidotus Gigas, *Ag.* P. foss. ii. p. 235. t. 28, 29. *Walchn.* p. 628. *Goldf.* ap. *Dech.* p. 419. *Bron.* Leth. ii. p. 486. Cyprinus Elvensis, *DeBl.* Ichth. p. 90. *Krug.* Natg. p. 214. *Holl.* p. 123. (Lias.) Northampton. (Boll. Elve. Mistelbach. Schwarzbach. Banz. Altdorf.)

Lepidotus latimanus, *Egert.* Msc. (Oxf. cl.) Chippenham.

Lepidotus Mantellii, *Ag.* P. foss. ii. p. 262. t. 30. f. 10–15; t. 30*a*. f. 4–6; t. 30*b*. f. 2; t. 30*c*. f. 1–7. *Mant.* Tilg. t. 5. f. 3, 4, 15, 16. *Park.* Org. Rem. iii. t. 18. f. 19. (Weald.) Tilgate.

Lepidotus minor, *Ag.* P. foss. ii. p. 260. t. 34. (Ool.) Stonesfield. Purb. Portl. (Hildesheim.)

Lepidotus rugosus, *Ag.* P. foss. ii. p. 246. t. 33*a*. f. 1–8. (Lias.) Lyme Regis. Whitby.

Lepidotus semiserratus, *Ag.* P. foss. ii. p. 240. t. 29*a*, 29*b*. *Young*, Geol. York. t. 16. f. 7, 8. (L. latissimus et umbonatus, *Ag.* l. c. p. 8. ? Palæoniscus, *Ag.* l. c. p. 82.) (Lias.) Whitby. Scarborough. Lottus, &c.

Lepidotus serrulatus, *Ag.* Msc. (Lias.) Barrow.

Lepidotus subdenticulatus, *Ag.* P. foss. ii. p. 9. t. 30. f. 4–6. L. Fittoni, *Mant.* (Hast. s.) Hastings.

Lepidotus tuberculatus, *Ag.* P. foss. ii. p. 256. t. 29*c*. f. 7. (Gr. ool.) Stonesfield.

Lepidotus undatus, *Ag.* P. foss. ii. p. 245. t. 33. (Lias.) Lyme Regis. (Jur. ? Caen.)

Lepidotus unguiculatus, *Ag.* P. foss. ii. p. 251. t. 30. f. 7–9; t. 29*c*. f. 1. Lepidosaurus, *H. v. Mey.* Palæol. p. 208. *Rupp.* Abbild. u. Beschr. p. 11. t. 4. (L. maximus, *Ag.*) (Gr. ool.) Stonesfield. (Jur. Solenhofen. Daitingen.)

Pholidophorus Bechei, *Ag.* P. foss. ii. p. 272. t. 39. f. 1–4. Geol. Tr. (2nd ser.) i. t. 7. f. 1. (Lias.) Lyme Regis.

Pholidophorus Flesheri, *Ag.* P. foss. ii. p. 281. t. 37. f. 8. (Inf. ool.) Northampton.

Pholidophorus Hastingsiæ, *Ag.* P. foss. ii. p. 284. t. 42*a*. f. 1. (Lias.) Barrow.

Pholidophorus latiusculus, *Ag.* P. foss. ii. p. 9, 287. (Lias.) Lyme Regis. (Seefeld.)

Pholidophorus leptocephalus, *Ag.* P. foss. ii. p. 288. (Lias.) Street.

Pholidophorus limbatus, *Ag.* P. foss. ii. p. 9, 282. t. 37. f. 1–5. (Lias.) Lyme Regis.

Pholidophorus minor, *Ag.* P. foss. ii. p. 286. t. 42*a*. f. 5. (Gr. ool.) Stonesfield.

Pholidophorus onychius, *Ag.* P. foss. ii. p. 274. t. 39. f. 5–7. (Lias.) Lyme Regis.

Pholidophorus ornatus, *Ag.* P. foss. ii. p. 280. t. 37. f. 6, 7. (Ool.) Purbeck.

Pholidophorus Stricklandi, *Ag.* P. foss. ii. p. 284. t. 42*a*. f. 3, 4. (Lias.) Barrow.

Pholidophorus pachysomus, *Egert.* Msc. *Ag.* P. foss. ii. p. 288. (Lias.) Lyme Regis.

Pholidophorus crenulatus, *Egert.* Msc. *Ag.* P. foss. ii. p. 288. (Lias.) Lyme Regis.

Nothosomus octostychius, *Ag.* Msc. P. foss. ii. p. 294. (Lias.) Street.

Ophiopsis dorsalis, *Ag.* P. foss. ii. p. 291. t. 36. f. 5. (Ool. inf.) Northampton?

Ophiopsis penicillatus, *Ag.* P. foss. ii. p. 290. t. 36. f. 2–4. (Ool.) Purbeck.

Sauroïdes.

Eugnathus Chirotes, *Ag.* P. foss. ii. t. 57*b*. (Lias.) Lyme Regis.

Eugnathus fasciculatus, *Ag.* Msc. (Lias.) Whitby.

Eugnathus leptodus, *Ag.* Msc. (Lias.) Lyme Regis.

Eugnathus mandibularis, *Ag.* Msc. (Lias.) Lyme Regis.

Eugnathus minor, *Ag.* P. foss. ii. t. 58*a*. f. 1. (Lias.) Lyme Regis.

Eugnathus opercularis, *Ag.* Msc. (Lias.) Lyme Regis.

Eugnathus ornatus, *Ag.* Msc. (Lias.) Lyme Regis.

Eugnathus orthostomus, *Ag.* P. foss. ii. t. 57*a*. (Lias.) Lyme Regis.

Eugnathus Philpotiæ, *Ag.* P. foss. ii. t. 58. (Lias.) Lyme Regis.

Eugnathus polyodon, *Ag.* P. foss. ii. t. 58*a*. f. 2. (Lias.) Lyme Regis.

Eugnathus scabriusculus, *Ag.* Msc. (Lias.) Lyme Regis.

Eugnathus speciosus, *Ag.* P. foss. ii. t. 56. f. 1–6. (Lias.) Lyme Regis.

Eugnathus tenuidens, *Ag.* P. foss. ii. (Lias.) Street.

Ptycholepis Bollensis, *Ag.* P. foss. ii. p. 11. t. D. f. 2. *Bron.* Leth. ii. p. 488. t. 24. f. 8. (Lias.) Lyme Regis. Whitby. (Boll.)

Conodus ferox, *Ag.* Msc. (Lias.) Lyme Regis.

Pachycormus acutirostris, *Ag.* Msc. (Lias.) Whitby.

Pachycormus curtus, *Ag.* P. foss. ii. t. 59. (Lias.) Whitby.

Pachycormus gracilis, *Ag.* P. foss. ii. p. 12. (Uræus gracilis, *Ag.* Cat.) (Lias.) Whitby. (Würtemberg.)

Pachycormus heterurus, *Ag.* P. foss. ii. t. 58*a*. f. 4. (Lias.) Lyme Regis.

Pachycormus latipennis, *Ag.* Msc. (Lias.) Lyme Regis.

Pachycormus latirostris, *Ag.* Msc. (Lias.) Whitby.

Pachycormus latus, *Ag.* Msc. (Lias.) Whitby.

Pachycormus leptosteus, *Ag.* Msc. (Lias.) Lyme Regis.

Pachycormus macrurus, *Ag.* P. foss. ii. t. 58*a*. f. 3. (Lias.) Lyme Regis.

Caturus Bucklandi, *Ag.* Msc. (Lias.) Lyme Regis.
Caturus pleiodus, *Ag.* Msc. (Ool.) Stonesfield.
Caturus angustus, *Ag.* Msc. (Pachycormus angustus olim.) (Portl.) Garsington.
Thrissonotus Colei, *Ag.* Msc. (Lias.) Lyme Regis.
Amblysemius gracilis, *Ag.* Msc. (Ool.) Northampton.
Sauropsis latus, *Ag.* P. foss. ii. p. 11. (Lias.) ? Lyme Regis. (Würtemb. Baden.)
Sauropsis mordax, *Ag.* Msc. (Gr. ool.) Stonesfield.
Leptolepis Bronnii, *Ag.* P. foss. ii. p. 13. Cyprinus coryphænoides, *Bron.* (Lias.) Lyme Regis. (Neidingin. Baireuth. Caen, &c.)
Leptolepis caudalis, *Ag.* Msc. (Lias.) Lyme Regis.
Leptolepis filipennis, *Ag.* Msc. (Lias.) Street.
Leptolepis macrophthalmus, *Egert.* (Oxf. cl.) Chippenham.
Saurostomus (sp. ined.), *Ag.* Msc. (Lias.) Lincolnshire.
Aspidorhynchus anglicus, *Ag.* Msc. (Lias.) Whitby.
Aspidorhynchus euodus, *Egert.* Msc. (Oxf. cl.) Chippenham.
Belonostomus acutus, *Ag.* Msc. (Lias.) Whitby.
Belonostomus leptosteus, *Ag.* Msc. (Ool.) Stonesfield.
Belonostomus tenellus, *Ag.* Msc. (B. Anningiæ olim.) (Lias.) Lyme Regis.
Macrosemius brevirostris, *Ag.* Msc. (Ool.) Stonesfield.

Cœlacanthes.

Ctenolepis Cyclus, *Ag.* Msc. (Ool.) Stonesfield.
Gyrosteus mirabilis, *Ag.* Msc. (Lias.) Whitby. Lyme Regis.

Pycnodontes.

Gyrodus Mantellii, *Ag.* P. foss. ii. t. 60*a.* f. 18. (Ool.) Tilgate.
Gyrodus Cuvieri, *Ag.* P. foss. ii. p. 16. t. 60*a.* f. 21–23. (Ool.) Sandfort. (Jur. m. Boulogne.)
Gyrodus radiatus, *Ag.* P. foss. ii. t. 60*a.* f. 20. (Ool.) Purbeck. Stonesfield. (Caen.)
Gyrodus trigonus, *Ag.* P. foss. ii. t. 60*a.* f. 15. (Ool.) Stonesfield.
Gyrodus umbilicus, *Ag.* P. foss. ii. p. 16. t. 60*a.* f. 27, 28. *Bron.* Leth. ii. p. 493. t. 25. f. 11. (Ool.) Stonesfield. (Dürrheim.)
Gyrodus punctatus, *Ag.* P. foss. ii. t. 69*a.* f. 24. (Ool.) Malton.
Sphærodus Gigas, *Ag.* P. foss. ii. p. 15. *Merc.* De Buf. p. 184. *Barr.* t. 2. n. 9. *Brück.* Ep. 64. t. 1. no. 6, 7. ?*Park.* Org. Rem. iii. t. 19. f. 6. (Ool.) Stonesfield. (Kim.) Shotover. (Jur. sup. Suisse.)
Sphærodus microdon, *Ag.* Msc. (Lias.) Lyme Regis.
Sphærodus minor, *Ag.* Msc. (Ool.) Stonesfield.
Gyronchus oblongus, *Ag.* P. foss. ii. t. 60*a.* f. 10, 11. (Scaphodus olim.) (Ool.) Stonesfield.
Microdon radiatus, *Ag.* P. foss. ii. t. 59*c.* f. 1, 2. (Ool.) Stonesfield. Purbeck.
Microdon trigonus, *Ag.* Msc. (Pycnodus.) (Ool.) Stonesfield.
Periodus marginalis, *Ag.* Msc. (Ool.) Dundry? Stonesfield?
Pycnodus Bucklandi, *Ag.* P. foss. ii. p. 16. t. 72*a.* f. 15–22. *Prév.* Ann. Sc. nat. xviii. no. 8. *Bron.* Leth. ii. p. 494. t. 25. f. 3. (Ool.) Stonesfield. (Caen.)
Pycnodus didymus, *Ag.* P. foss. ii. t. 72*a.* f. 24, 25. (Ool.) Stonesfield.
Pycnodus Hugii, *Ag.* P. foss. ii. p. 17. t. 72*a.* f. 49–54. (Ool.) Stonesfield. (Jur. Soleure. Portl. Le Banné. Villars.)
Pycnodus latirostris, *Ag.* Msc. (Ool.) Stonesfield.
Pycnodus Mantellii, *Ag.* P. foss. ii. t. 72*a.* f. 6–14. *Mant.* Tilg. t. 17. f. 26, 27. (=P. microdon, *Ag.* l. c. p. 17.) (Ool.) Tilgate. Sussex. (Ratisbonne.)
Pycnodus obtusus, *Ag.* Msc. (Ool.) Stonesfield.
Pycnodus ovalis, *Ag.* P. foss. ii. t. 72*a.* f. 5. (Ool.) Stonesfield.
Pycnodus parvus, *Ag.* Msc. (Ool.) Stonesfield.
Pycnodus rugulosus, *Ag.* P. foss. ii. t. 72*a.* f. 23. (Ool.) Stonesfield. Northampton.
Pycnodus tristychius, *Ag.* Msc. (F. marble.)
Pycnodus umbonatus, *Ag.* P. foss. ii. p. 16. t. 72*a.* f. 1–4. (Ool.) Stonesfield. Yorkshire. (Jur. m. Normandie.)
Pycnodus biserialis, *Ag.* Msc. (Ool.) Little Gibraltar near Oxford.
Pycnodus discoides, *Ag.* Msc. (Ool.) Little Gibraltar near Oxford.

Acipensérides.

Chondrosteus acipenseroides, *Ag.* Msc. (Lias.) Lyme Regis.

CRETACEOUS SYSTEM.

I. Placoïdes.

Ichthyodorulithes.

Ptychodus acutus, *Egert.* *Ag.* P. foss. iii. p. 177. (Gault.) Folkstone.
Ptychodus spectabilis, *Ag.* P. foss. iii. p. 57. t. 10*a.* f. 1, 3. (Cr.) Lewes.

Ptychodus gibberulus, *Ag.* P. foss. iii. p. 58. t. 10*a*. f. 4. (Cr.) Lewes.
Ptychodus arcuatus, *Ag.* P. foss. iii. p. 58. t. 10*a*. f. 2. (Cr.) Lewes.
Ptychodus articulatus, *Ag.* P. foss. iii. p. 58. t. 10*a*. f. 5, 6. (Cr.) Lewes.
Hybodus sulcatus, *Ag.* P. foss. iii. p. 44. t. 10*b*. f. 15, 16. (Cr.) Lewes.
Chimæra (Psittacodon) Mantellii, *Buckl.* Proc. Geol. Soc. ii. p. 206. *Ag.* P. foss. iii. p. 348. t. 40*a*. f. 1, 2. (Cr. bl.) Kent.
Spinax major, *Ag.* P. foss. iii. p. 62. t. 10*b*. f. 8–14; t. 40*a*. f. 6–8. (Cr.) Lewes.

Cestraciontes.

Ptychodus mammillaris, *Ag.* P. foss. iii. p. 151. t. 25*b*. f. 11–20. *Park.* Org. Rem. iii. t. 18. f. 12. *Mant.* South. D. t. 32, 39, 40. ? Pt. Knorrii, *Sternb.* Verh. Nat. Mus. Böhm. 1829. t. 1. f. 5. (Cr. bl.) Sussex. Kent. (Cr. Paris. Quedlinburg. Belluno. Bennatek. Delaware. Plän. Strehla.)
Ptychodus decurrens, *Ag.* P. foss. iii. p. 154. t. 25*b*. f. 1–8. (Cr.) Sussex. (Passy. Bennatek. Belluno. Mount Saint Catherine. Gr. v. Bockum. Ratisbon. Quedlinburg.)
Ptychodus altior, *Ag.* P. foss. iii. p. 155. t. 25*b*. f. 9, 10. *Mant.* South. D. t. 32. f. 17, 21, 27. (Cr.) Sussex.
Ptychodus polygyrus, *Ag.* P. foss. iii. p. 156. t. 25*b*. f. 21–23; t. 25. f. 4–11. *Park.* Org. Rem. iii. t. 19. f. 18. *Brückm.* Ep. 64. t. 4. no. 5. *Mant.* South. D. t. 32. f. 23, 24. (Cr.) Sussex. Kent. Cambridge. (Belgique.)
Ptychodus latissimus, *Ag.* P. foss. iii. p. 157. t. 25*a*; t. 25*b*. f. 24–26. *Mant.* t. 32. f. 19. Pt. Schlotheimii, *Münst.* (Cr.) Sussex. (Belgique. Bockum. Belluno. Bennatek.)
Acrodus transversus, *Ag.* P. foss. iii. (oublié dans le texte) t. 10*b*. f. 4, 5. (Cr. bl.) Lewes.
Strophodus asper, *Ag.* P. foss. iii. p. 128*b*. t. 10*b*. f. 1–3. (Psammodus asper). (Cr. bl.) Lewes.
Strophodus sulcatus, *Ag.* P. foss. iii. p. 176. (Gr. v.) Maidstone.

Squalides.

Scylliodus antiquus, *Ag.* P. foss. iii. p. 378. t. 38. (Cr.) Kent. Burham.
Notidanus microdon, *Ag.* P. foss. iii. p. 221. t. 27. f. 1; t. 36. f. 1, 2. (Cr.) Sussex. Kent. Cambridge. (Quedlinburg.)
Notidanus pectinatus, *Ag.* P. foss. iii. p. 221. t. 36. f. 3. (Cr.) Angleterre.
Corax falcatus, *Ag.* P. foss. iii. p. 226. t. 26*a*. f. 1–15; t. 26. f. 14. (Galeus pristodontus). (Cr. bl.) Brighton. Kent. (Cr. Quedlinburg. Pl. Strehla.)
Otodus appendiculatus, *Ag.* P. foss. iii. p. 270. t. 32. f. 1–25. (Cr.) Sussex. Kent. Cambridge. (Gault.) Speeton. (Cr. Maëstricht. Aix-la-Chapelle. Delaware. Normandie. Gr. v. Essen. Quedlinburg. Plän. Strehla, &c.
Oxyrhina Mantellii, *Ag.* P. foss. iii. p. 280. t. 33. f. 1–9. (Lamna crassissima olim.) (Cr.) Sussex, &c.
Lamna acuminata, *Ag.* P. foss. iii. p. 292. t. 37*a*. f. 54–57. *Mant.* Geol. Suss. t. 32. f. 1. (Squalus cornubicus.) Cœloptychium acaule, *Goldf.* Petr. Germ. i. p. 220. t. 65. f. 12. *Ag.* in *Leon. u. Br.* Jahrb. 1834. p. 382. *Bron.* Leth. ii. p. 743. t. 27. f. 24. (Cr. bl.) Kent. Sussex. Yorkshire. (Gr. v.) Prewsey. (Cr. Maëstricht. Quedlinburg. Aix-la-Chapelle. Amérique Nord. Plän. Saxe.)
Lamna (Odontaspis) raphiodon, *Ag.* P. foss. iii. p. 296. t. 37*a*. f. 11–16. *Bron.* Leth. ii. p. 744. Squalus rhaphiodon, *Ag.* (Coll. *Bron.*) Squale Roussette, *Fauj.* Mt. St. Pierre, p. 110. t. 18. f. 2. (Cr. bl.) Lewes. (Delaware. Gr. v. Ratisbonne.)
Lamna (Odontaspis) subulata, *Ag.* P. foss. iii. p. 296. t. 37*a*. f. 5–7. (Gr. v.) Bognor. (Ratisbonne. Cr. marn. Quedlinburg.)

Chimérides.

Chimæra (Ischyodon) Agassizii, *Buckl.* Proc. Geol. Soc. ii. p. 206. *Ag.* P. foss. iii. p. 341. t. 40*a*. f. 3–5; t. 40*c*. f. 14–16. (Gr. v.) Maidstone.
Chimæra (Ischyodon) brevirostris, *Ag.* P. foss. iii. p. 344. (Gault.) Folkstone.
Chimæra (Ischyodon) Gigas, *Egert.* Msc. (Cr.) Sussex.
Chimæra (Psittacodon) Mantellii, *Buckl.* Proc. Geol. Soc. p. 206. *Ag.* P. foss. iii. p. 348. t. 40*a*. f. 1, 2. (Cr. bl.) Kent.
Chimæra (Psittacodon) Sedgwickii, *Ag.* P. foss. iii. p. 349. t. 40. f. 17, 18. (Cr.) Cambridge.

II. Ganoïdes.

Lépidoïdes.

Lepidotus punctulatus, *Ag.* Msc. (Cr.) Burham. Kent.

Sauroïdes.

Caturus similis, *Ag.* P. foss. ii. t. 66*a*. f. 9. (Cr.) Lewes.

Cœlacanthes.

Macropoma Mantellii, *Ag.* P. foss. ii. t. 65*a*, 65*b*, 65*c*, 65*d*. *Bron.* Leth. ii. Amia Lewesiensis, *Mant.* Geol. Suss. t. 38, 37. (Coprol.) t. 9. f. 5–11. Geol. Tr. iii. p. 207. Geol. S. E. Engl. p. 142, 377. (Cr. bl.) Lewes. (Cr.) Sussex. Cambridge. Chimay.

Macropoma Egertoni, *Ag.* Msc. (Gault.) Speeton.

Pycnodontes.

Acrotemnus Faba, *Ag.* P. foss. ii. t. 66*a*. f. 16–18. (Cr.) Lewes.

Gyrodus angustus, *Ag.* P. foss. ii. t. 66*a*. f. 14, 15. (Cr.) Lewes. Maidstone.

Gyrodus cretaceus, *Ag.* P. foss. ii. t. 60*a*. f. 13. (Cr.) Lewes.

Gyrodus mammillaris, *Ag.* P. foss. ii. t. 73. f. 1, 2. (Sphærodus mammillaris olim.) (Cr.) Clayton. (Cr. bl.) Lewes.

Gyrodus minor, *Ag.* P. foss. ii. p. 16. t. 60*a*. f. 14. *Phill.* Geol. York. (Speet. cl.) Yorkshire.

Pycnodus angustus, *Ag.* Msc. *Fauj.* t. 19. f. 2. Burt. t. 1. S. *Lind.* 1399. (Cr. bl.) Kent. (Cr. Maëstr. Aix-la-Chapelle.)

Pycnodus cretaceus, *Ag.* P. foss. ii. t. 72*a*. f. 60. (Cr. bl.) Kent.

Pycnodus elongatus, *Ag.* Msc. (Cr. bl.) Lewes.

Pycnodus minor, *Ag.* Msc. (Speet. cl.) Speeton.

Pycnodus subclavatus, *Ag.* P. foss. ii. t. 72*a*. f. 59. (Cr. bl.) Kent. (Cr. Maëstricht.)

Sphærodus . . . . . , *Ag.* Msc. (Cr. bl.) Lewes.

Sclérodermes.

Dercetis elongatus, *Ag.* P. foss. ii. t. 66*a*. f. 1–8. *Bron.* Leth. ii. Muræna Lewesiensis, *Mant.* Geol. Suss. t. 40. f. 2; t. 34. f. 10, 11. Geol. Tr. iii. p. 207. Geol. S. E. Engl. p. 377. (Cr. bl.) Lewes. Sussex.

III. Cténoïdes.

Percoïdes.

Beryx ornatus, *Ag.* P. foss. iv. p. 115. t. 14*a*; t. 14*b*. f. 2; t. 14*c*. f. 1–6; t. 14*d*. Zeus Lewesiensis, *Mant.* Geol. Suss. t. 34. f. 6; t. 35, 36. Geol. Tr. viii. p. 207. Geol. S. E. Engl. p. 136, 377. (Cr. bl.) Sussex. Kent. (Continent. Bohème, &c.)

Beryx radians, *Ag.* P. foss. iv. p. 118. t. 14*c*. f. 7–9; t. 14*b*. f. 7. (Cr. bl.) Lewes. Kent.

Beryx microcephalus, *Ag.* P. foss. iv. p. 119. t. 14*b*. f. 3–6; t. 14*c*. f. 10. (Cr.) Lewes. Kent.

IV. Cycloïdes.

Hypsodon Lewesiensis, *Ag.* P. foss. v. t. 25*a*, 25*b*. (Megalodon et Cladocyclus olim.) = H. sauroides, *Ag.* *Mant.* t. 42. f. 1–5; t. 33. f. 8. (Cr.) Lewes.

Enchodus Halocyon, *Ag.* P. foss. v. t. 25*c*. f. 1–16. Esox Lewesiensis, *Mant.* Geol. Suss. t. 44. f. 1, 2; t. 33. f. 2–4; Geol. Trans. iii. p. 207; Geol. S. E. Engl. p. 140, 377. (Cr.) Lewes. Sussex. Norfolk. (Belgique. Maëstricht. Amérique Nord.)

Saurocephalus lanciformis, *Harl.* J. Philad. iii. p. 331. t. 3. f. 1–5. (? S. cuneiformis.) *Ag.* P. foss. v. t. 25*c*. f. 21–29. *Mant.* Geol. Suss. t. 33. f. 7, 9. *Brewst.* J. i. p. 382. *Féruss.* Bull. iv. p. 32. *Krüg.* Urw. Nat. ii. p. 253. *Holl.* p. 91. *Wagl.* Syst. Amph. p. 140. *Harl.* Edinb. Phil. J. xviii. p. 28. *H. v. Mey.* Pal. p. 114, 222. *Bron.* Leth. ii. p. 751. (Cr.) Lewes. (New Jersey.)

Saurocephalus striatus, *Ag.* P. foss. v. t. 25*c*. f. 17–20. (Cr.) Lewes. (New Jersey.)

Saurodon Leanus, *Hays.* Tr. Amer. Phil. Soc. 1830. iii. p. 476. t. 19. *Ag.* P. foss. v. t. 25*c*. f. 30, 31. *Féruss.* Bull. xxii. p. 127. *Leon. u. Br.* Jahrb. xviii. p. 246. *H. v. Mey.* Pal. p. 114, 223. *Ag.* in *L. u. Br.* Jahrb. 1835. p. 107. *Harl.* Tr. Geol. Philad. i. Edinb. N. Phil. Journ. xviii. p. 28. *Bron.* Leth. ii. p. 752. (Cr. bl.) Lewes. (Amérique Nord.)

Tetrapterus minor, *Ag.* P. foss. v. t. 60*a*. f. 9–13. (Cr. bl.) Lewes.

Acrognathus boops, *Ag.* P. foss. v. t. 60*a*. f. 1–4. (Cr.) Lewes.

Aulolepis Typus, *Ag.* P. foss. v. t. 60*a*. f. 5–8. (Cr.) Clayton. Lewes. Burham.

Osmeroides Lewesiensis, *Ag.* P. foss. v. t. 60*b*, 60*c*. (Halec olim.) Salmo Lewesiensis, *Mant.* Geol. Suss. t. 40. f. 1; t. 33. f. 12; t. 34. f. 1–3. Geol. Tr. iii. p. 207. Geol. S. E. Engl. p. 138, 377. O. Mantelli, *Egert.* Cat. (Cr.) Lewes. Sussex.

Osmeroides granulatus, *Ag.* Msc. (Cr. bl.) Lewes.

TERTIARY SYSTEM.

I. Placoïdes.

Ichthyodorulithes.

Myliobates toliapicus, *Ag.* P. foss. iii. p. 331. t. 47. f. 15–20; p. 331. t. 45. f. 21–23. (Lond. cl.) Sheppy.
Myliobates Owenii, *Ag.* P. foss. iii. p. 331. t. 45. f. 11–13. (Lond. cl.) Sheppy.
Myliobates acutus, *Ag.* P. foss. iii. p. 331. t. 45. f. 14–17. (Lond. cl.) Sheppy.
Myliobates canaliculatus, *Ag.* P. foss. iii. p. 331. t. 45. f. 18–20. (Lond. cl.) Sheppy.
Myliobates lateralis, *Ag.* P. foss. iii. p. 331. t. 45. f. 24–27. (Lond. cl.) Sheppy.
Myliobates marginalis, *Ag.* P. foss. iii. p. 331. (Lond. cl.) Barton. Sheppy.
Zygobates Woodwardii, *Ag.* P. foss. iii. p. 329, 333. t. R. f. 6, 7. (Crag.) Norfolk.

Squalides.

Notidanus serratissimus, *Ag.* P. foss. iii. p. 222. t. 36. f. 4, 5. (Lond. cl.) Sheppy.
Glyphis hastalis, *Ag.* P. foss. iii. p. 244. t. 36. f. 10–13. (Lond. cl.)
Carcharodon toliapicus, *Ag.* P. foss. iii. p. 257. t. 30*a*. f. 14. (Lond. cl.) Sheppy.
Carcharodon subserratus, *Ag.* P. foss. iii. p. 260. t. 36. f. 14, 15. (Carcharias subserratus, *Ag.* in *Egert.* Cat.) (Lond. cl.) Sheppy.
Otodus obliquus, *Ag.* P. foss. iii. p. 267. t. 31; t. 36. f. 22–27. (Lond. cl.) Sheppy.
Otodus macrotus, *Ag.* P. foss. iii. p. 273. t. 32. f. 29–31. (Lond. cl.) Sheppy. (C. gr. Véteuil. Chaumont. Parme.)
Lamna elegans, *Ag.* P. foss. iii. p. 289. t. 35. f. 1–7; t. 37*a*. f. 58, 59. (Lond. cl.) Sheppy. (C. gr. Paris. Grignon. Dax. Bordeaux, &c. Italie.)
Lamna compressa, *Ag.* P. foss. iii. p. 290. t. 37*a*. f. 35–42. (Lond. cl.) Sheppy. (C. gr. Chaumont.)
Lamna (Odontaspis) Hopei, *Ag.* P. foss. iii. p. 293. t. 37*a*. f. 27–30. (Lond. cl.) Sheppy.
Lamna (Odontaspis) verticalis, *Ag.* P. foss. iii. p. 294. t. 37*a*. f. 31, 32. (Lond. cl.) Sheppy.
Lamna (Odontaspis) contortidens, *Ag.* P. foss. iii. p. 294. t. 37*a*. f. 17–23. (Crag.) Angleterre. (Mol. Suisse. Grav. Flonheim. C. mol. Thiengen.)
Pristis bisulcatus, *Ag.* P. foss. iii. p. 382*. t. 41. (Lond. cl.) Sheppy.
Pristis acutidens, *Ag.* P. foss. iii. p. 382**. (Sabl.) Bagshot.
Pristis Hastingsiæ, *Ag.* P. foss. iii. p. 382*. (Lond. cl.) Sheppy. Hampshire.

Raies.

Myliobates toliapicus, *Ag.* P. foss. iii. p. 321. t. 47. f. 15–20; p. 331. t. 45. f. 21–23. (Lond. cl.) Sheppy.
Myliobates goniopleurus, *Ag.* P. foss. iii. p. 319. t. 47. f. 9, 10. (Lond. cl.) Sheppy.
Myliobates Dixoni, *Ag.* P. foss. iii. p. 319. (Lond. cl.) Sussex.
Myliobates striatus, *Ag.* P. foss. iii. p. 320. *Buckl.* Min. Geol. t. 27*d*. f. 14. (Lond. cl.) Sheppy.
Myliobates punctatus, *Ag.* P. foss. iii. p. 322. t. 47. f. 11, 12. (Lond. cl.) Sheppy.
Myliobates gyratus, *Ag.* P. foss. iii. p. 323. t. 46. f. 1–3. (Lond. cl.) Sheppy.
Myliobates jugalis, *Ag.* P. foss. iii. p. 324. t. 47. f. 13, 14. (? M. heteropleuri, var.) (Lond. cl.) Sheppy.
Myliobates nitidus, *Ag.* P. foss. iii. p. 325. (Lond. cl.) Sheppy. Barton.
Myliobates Colei, *Ag.* P. foss. iii. p. 325. (Lond. cl.) Sheppy.
Myliobates heteropleurus, *Ag.* P. foss. iii. p. 323. t. 47. f. 6–8. (Lond. cl.) Sheppy?
Aëtobatis irregularis, *Ag.* P. foss. iii. p. 327. t. 47. f. 3–5. (Lond. cl.) Sheppy. Sussex.
Aëtobatis subarcuatus, *Ag.* P. foss. iii. p. 328. (Lond. cl.) Sheppy. Barton.
Zygobates Woodwardii, *Ag.* P. foss. iii. p. 329, 333. t. R. f. 6, 7. (Crag.) Norfolk.
Raja antiqua, *Ag.* P. foss. iii. p. 371. t. 37. f. 33. (Crag.) Norfolk.

Chimérides.

Elasmodus Hunterii, *Egert.* *Ow.* Odontogr. p. 66. *Ag.* P. foss. iii. p. 350. (Lond. cl.) Sheppy.
Edaphodon Bucklandii, *Ag.* P. foss. iii. p. 351. t. 40*d*. f. 1–4, 9–12, 19–24. Ed. latidens, *Buckl.* (Sabl.) Bagshot.
Edaphodon eurygnathus, *Ag.* P. foss. iii. p. 352. (Lond. cl.) Sussex.
Edaphodon leptognathus, *Ag.* P. foss. iii. p. 352. t. 40*d*. f. 5–8, 13–18. Ed. angustidens, *Buckl.* (Sabl.) Bagshot.
Passalodon rostratus, *Ag.* P. foss. iii. p. 352. (Sabl.) Bagshot.
Psaliodus compressus, *Egert.* *Ag.* P. foss. iii. p. 351. (Lond. cl.) Sheppy.

II. Ganoïdes.

Pycnodontes.

Phyllodus irregularis, *Ag.* Msc. (Lond. cl.) Sheppy.
Phyllodus medius, *Ag.* Msc. (Lond. cl.) Sheppy.

Phyllodus marginalis, *Ag.* P. foss. ii. t. 60*a.* f. 8–9. (Lond. cl.)
Phyllodus planus, *Ag.* P. foss. ii. t. 60*a.* f. 4, 5. (Lond. cl.)
Phyllodus polyodus, *Ag.* P. foss. ii. t. 60*a.* f. 6, 7. (Lond. cl.)
Phyllodus toliapicus, *Ag.* P. foss. ii. t. 60*a.* f. 1–3. (Lond. cl.) Sheppy.
Pycnodus toliapicus, *Ag.* P. foss. ii. t. 72*a.* f. 55. (Lond. cl.) Sheppy.
Periodus Kœnigii, *Ag.* P. foss. ii. t. 72*a.* f. 61, 62. (Lond. cl.) Sheppy.
Gyrodus lævior, *Ag.* P. foss. ii. t. 69*a.* f. 12. (Lond. cl.) Sheppy.
Pisodus Oweni, *Ag.* *Ow.* Odont. p. 138. t. 47. (Lond. cl.) Hampshire.

Acipensérides.

Acipenser toliapicus, *Ag.* Msc. (Lond. cl.) Sheppy.

Sclérodermes.

Glyptocephalus radiatus, *Ag.* Msc. (Lond. cl.) Sheppy.

III. Ctenoïdes.

Sciénoides.

Sciænurus Bowerbankii, *Ag.* Msc. (Lond. cl.) Sheppy.
Sciænurus crassior, *Ag.* Msc. (Lond. cl.) Sheppy.

Chétodontes.

Platax Woodwardii, *Ag.* P. foss. iv. p. 250. t. 19. f. 3. (Crag.) Norfolk.

IV. Cycloïdes.

Scombéroïdes.

Cybium macropomum, *Ag.* P. foss. v. t. 26. f. 1–3. (Lond. cl.) Sheppy.
Sphyrænodus priscus, *Ag.* P. foss. v. (Dictyodus, *Ow.*) t. 26. f. 4–6. (Lond. cl.) Sheppy.
Sphyrænodus crassidens, *Ag.* Msc. (Lond. cl.) Sheppy.
Hypsodon oblongus, *Ag.* Msc. (Lond. cl.) Sheppy.
Hypsodon toliapicus, *Ag.* Msc. (Lond. cl.) Sheppy.
Tetrapterus priscus, *Ag.* P. foss. v. t. 31. f. 1–3. (Lond. cl.) Sheppy.
Goniognathus coryphænoides, *Ag.* Msc. (Lond. cl.) Sheppy.
Goniognathus maxillaris, *Ag.* Msc. (Lond. cl.) Sheppy.
Cœlorhynchus rectus, *Ag.* Msc. (Lond. cl.) Sheppy.
Cœlorhynchus sinuatus, *Ag.* Msc. (Lond. cl.) Sheppy.

Clupéoïdes.

Megalops priscus, *Ag.* Msc. (Lond. cl.) Sheppy.
Halecopsis lævis, *Ag.* Msc. (Lond. cl.) Sheppy.
Cœlocephalus salmoneus, *Ag.* Msc. (Lond. cl.) Sheppy.

Genera adhuc incertæ sedis.

Cœlopoma Colei, *Ag.* Msc. (Lond. cl.) Sheppy.
Cœlopoma læve, *Ag.* Msc. (Lond. cl.) Sheppy.
Brachygnathus tenuiceps, *Ag.* Msc. (Lond. cl.) Sheppy.
Rhynchorhinus branchialis, *Ag.* Msc. (Lond. cl.) Sheppy.
Pachycephalus cristatus, *Ag.* Msc. (Lond. cl.) Sheppy.
Podocephalus nitidus, *Ag.* Msc. (Lond. cl.) Sheppy.
Bothrosteus latus, *Ag.* Msc. (Lond. cl.) Sheppy.
Bothrosteus brevifrons, *Ag.* Msc. (Lond. cl.) Sheppy.
Rhinocephalus planiceps, *Ag.* Msc. (Lond. cl.) Sheppy.
Ampheristus toliapicus, *König.* Icon. Sect. (Lond. cl.) Sheppy.

Report on the British Fossil Mammalia.

By Richard Owen, *Esq., F.R.S.*

Part II. *Ungulata.*

Order Pachydermata.

Genus *Elephas.*

When the science of fossil organic remains was less advanced than it is at present, when its facts and generalizations were new, and sounded strange not only to the ears of the unscientific but to anatomists and naturalists, the announcement of the former existence of animals in countries where the like had not been known within the memory of man, still more of species not known to exist in any part of the world, was received with distrust and doubt, and many endeavours were made to explain the former phænomena by reference to known circumstances that might have led to the introduction of tropical animals into temperate zones within the historical period. When Cuvier first announced the existence of Elephants, Rhinoceroses and Hippopotamuses in the superficial unstratified deposits of continental Europe, he was reminded of the Elephants that were introduced into Italy by Pyrrhus in the Roman wars, and afterwards more abundantly, and with the stranger quadrupeds of conquered tropical countries, in the Roman triumphs and games of the amphitheatre. Cuvier's minute anatomical distinctions, proving the disinterred fossils to have belonged to extinct species of *Elephas, Hippopotamus, Rhinoceros,* &c., were at first hardly appreciated, and, by some of his contemporaries, were explained away or dissallowed. Cuvier, therefore, appealed with peculiar satisfaction to the testimonies and records of analogous Mammalian fossils in the British Isles, to the origin of which it was obvious that the hypothesis of Roman or other foreign introduction within the historical period could not be made applicable.

"If," says the founder of palæontological science, "passing across the German Ocean, we transport ourselves into Britain, which, in ancient history, by its position, could not have received many living elephants besides that one which Cæsar brought thither according to Polinæus*; we shall, nevertheless, find there fossils in as great abundance as on the continent."

Cuvier then cites the account given by Sir Hans Sloane of an elephant's fossil tusk, disinterred in Gray's Inn Lane, out of the gravel twelve feet below the surface. Sir Hans Sloane had obtained also the molars of an elephant from the county of Northampton, which were found in blue clay beneath vegetable mould and loam, from 3 to 6 feet below the surface; these specimens were explained by Dr. Cüper as having belonged to the identical elephant brought over to England by Cæsar; but Cuvier remarks that too many similar fossils had been found in England to render that conjecture admissible. He then proceeds to quote the instances recorded at the period of the publication of the 'Ossemens Fossiles.'

Dr. Buckland adds the weighty objection, that the remains of these Elephants are usually accompanied in England, as on the continent, by the bones of the Rhinoceros and Hippopotamus, animals which could never have been attached to Roman armies; and I may add, that the natural historians of Ireland, Neville and Molineux, made known in 1715 the existence of fossil molar teeth of the Elephant at Maghery, eight miles from Belturbet in the county of Cavan, and similar evidences of the Elephant have since been discovered in other localities of Ireland, where the armies of Cæsar never set foot. Some other hypothesis must therefore be resorted to in order to explain these phænomena.

* Lib. viii. c. 23. § 5. cited in Ossem. Fossiles, 4to, 1821, tom. i. p. 134.

Observation, which ought to precede all hypothesis, as it alone can form the basis of any sound one, has shown in the first place that the remains of the Elephants which are scattered over Europe in the unstratified superficial deposits called 'Diluvium,' 'Drift,' 'Till,' 'Glacio-diluvium,' as well as those from the upper tertiary strata, are specifically different from the teeth and bones of the two known existing Elephants, the *Elephas Indicus* and *El. Africanus*. This fundamental fact, when first appreciated by Cuvier, who announced it in 1796, opened to him, he says, entirely new views of the theory of the earth, and a rapid glance, guided by the new and pregnant idea, over other fossil bones, made him anticipate all that he afterwards proved, and determined him to consecrate to this great work the future years of his life.

The differences which the skull of the fossil Elephant presents as compared with the recent species are, the more angular form and relative shortness of the zygomatic processes; the longer, more pointed and more curved form of the postorbital process; the larger and more prominent tubercle of the lachrymal bone; the greater length of the sockets of the tusks; the more parallel position of the right and left sockets of the grinders, making the anterior interspace and channel at the junction of the rami of the lower jaw proportionably wider than in the existing Elephants. Of the differences in the conformation of the skull above enumerated, I have verified the last-mentioned instance, taken from the lower jaw, by observation of English specimens; they are well displayed in the lower jaw of a young Mammoth disinterred from a Pleistocene bed near Yarmouth in the county of Norfolk, and now in the possession of Mr. E. Stone, of Garlick Hill, London.

This lower jaw shows also that the outer contour of one ramus meets that of the other at a more open angle than in the African or Asiatic Elephant, and that the symphysis itself, though acute at this period of life, is less prolonged. In the older Mammoths the symphysis becomes obtuse; were it otherwise, the prolonged alveoli of the fully-developed tusks would have interfered with the motion of the lower jaw.

The difference between the extinct and existing species of Elephant in regard to the structure of the teeth, has been more or less manifested by every specimen of fossil elephant's tooth that I have hitherto seen from British strata, and those now amount to upwards of three thousand. Very few of them could be mistaken by a comparative anatomist for the tooth of an Asiatic Elephant, and they are all obviously distinct from the peculiar molars of the African Elephant.

Cuvier, who had recognized a certain range of variety in the structure of the numerous teeth of the Mammoth from continental localities, found nevertheless that the molars of the fossil Elephant were broader in proportion to their length or antero-posterior diameter than in the existing species; that the transverse plates were thinner and more numerous in the fossil molars than in those of the Indian Elephant; that a greater number of plates entered into the formation of the grinding surface of the tooth, and that the lines of enamel were less festooned; but to this character there are exceptions, especially in the large molars of aged individuals.

Varieties.—Question of Species.

The varieties to which the grinders of the different species of Elephants are subject in regard to the thickness and number of their plates, increase in the ratio of the average number of the plates which characterizes the molar teeth of the different species. Thus in the African Elephant, in which the lozenge-shaped plates are always much fewer and thicker than the flattened ones in the Indian species, the variation which can be detected in any number of the grinders of the same size is very slight.

In the Asiatic Elephant, which, besides the difference in the shape of the plates, has always thinner and more numerous plates than the African one, a greater amount of variation in both these characters obtains; but it is always necessary to bear in mind the caution which Cuvier suggested to Camper, that a large molar of an old elephant is not to be compared with a small molar of a young one, otherwise there will appear to be a much greater discrepancy in the thickness of the plates than really exists in the species; and the like caution is still more requisite in the comparison of the molars of the Mammoth or fossil Elephant (*Elephas primigenius*), which, having normally more numerous and thinner plates than in the existing Asiatic Elephant, present a much greater range of variety.

Of the extent of this variety in the British fossils some idea may be gained by the fact, that in one private collection, that of Miss Gurney of Cromer, of fossil Mammalian remains from a restricted locality, there are Mammoth's teeth from the drift of the adjacent coast, one of which, measuring 10 inches 9 lines in antero-posterior diameter, has nineteen plates, whilst another grinder, 11 inches in antero-posterior diameter, has only thirteen plates.

A greater contrast is presented by two grinders of the Mammoth from British diluvium in the collection of the late Mr. Parkinson, one of which, with a grinding surface of $5\frac{1}{2}$ inches in antero-posterior extent, exhibits the abraded summits of seventeen plates, whilst the other shows only nine plates in the same extent of grinding surface.

Some palæontologists have viewed these differences as indications of distinct species of *Elephas*. But the vast number of grinders of the Mammoth from British strata which have been in my hands in the course of the last three years have presented so many intermediate gradations, in the number of plates, between the two extremes above cited, that I have not been able to draw a well-defined line between the thick-plated and the thin-plated varieties of the molar teeth. And if these actually belonged to distinct species of Mammoth, they must have merged into one another, so far as the character of the grinding teeth is concerned, in a degree to which the two existing species of Elephant, the Indian and African, when compared together, offer no analogy.

Five or six molars of the Mammoth, and even a greater number, if the peculiar changes superinduced by friction on the grinding surface were not taken into account, might be selected from such a series as I have above referred to, as indications of as many distinct species of Mammoth: such specimens have been so interpreted by Parkinson, and likewise by Fischer, Goldfuss, Nesti and Croizet, cited in the *Palæologica* of Hermann V. Meyer, as authorities for eight distinct species of extinct Elephant.

We must, however, enter more deeply into the consideration of these varieties, before concluding that the Mammoths which severally exemplify them in their molar teeth were distinct species. In the first place, whatever difference the molars of the Mammoth from British strata have presented in the number of their lamellar divisions, they have corresponded in having a greater proportion of these plates on the triturating surface, and likewise, with two exceptions, in their greater proportional breadth, than the molars of the Asiatic Elephant present. The first exception here alluded to was from the diluvial gravel of Staffordshire, and formed part of the collection of Mr. Parkinson, the author of the 'Organic Remains;' the second exception was from the brick-earth of Essex, and is now in the collection of my friend Mr. Brown of Stanway; this molar, though it combines the thicker plates with the narrower form of the entire tooth characteristic of the Indian Elephant, differs in the greater extent of the grinding surface and the greater number of plates entering into the composition of that surface.

With regard to the first-cited exception, the following is the result of a close comparison instituted between it and a corresponding grinder of the Indian Elephant.

The fossil in question is an inferior molar of the right side of the lower jaw. It exhibits the most complete state in which so large a grinder can be met with, the anterior division of the crown not being quite worn down to the fang, and the hindmost plate being just on the point of coming into use. The whole length of the tooth is 13 inches; the total number of lamellar divisions of the crown seventeen, of which the summits of fourteen are abraded in a grinding surface of 9 inches' extent. The greatest breadth of this surface is $2\frac{1}{2}$ inches. The first three fangs supporting the common dentinal base of the anterior lamellæ are well developed. The transverse ridges of enamel are festooned. Compared with the thin-plated grinders of the Mammoth, these differ not only in their more numerous, thinner and broader plates, but likewise in the thicker coat of external cement which fills the lateral interspaces of the coronal plates, and in having the fangs developed from the whole base of the tooth, even from the posterior plate, the summit of the mammillary process of which has just begun to be abraded. But from the corresponding molar of the Indian Elephant the present tooth of the Mammoth differs in the more equable length of the coronal plates, which in the Elephant, by their more progressive elongation, give a triangular figure to the side-view of the crown; it differs also in the greater length of the grinding surface, which includes two additional plates, although these are not thinner and are not characterized by superior breadth as in the ordinary teeth of the Mammoth.

These differences from the teeth of the Indian Elephant, and the intermediate gradations in the fossil molars by which such rare extreme varieties are linked to the normal type of the Mammoth's dentition, justify us in rejecting the conclusion that the *Elephas Indicus* coexisted with the Mammoth in the latitude of England during the antediluvial or anteglacial epoch: and I think it probable that such differences as have been pointed out in the molar from the Museum of Parkinson, and that of the existing Elephant, might likewise have been detected in the large molar, found at the depth of 6 feet, in brick loam, at Hove near Brighton, and alluded to by Dr. Mantell as decidedly that of the Asiatic Elephant *. One of the molars from the Elephant bed at Brighton, now in the possession of Mr. Stone of Garlick Hill, exhibits the narrow-plated variety of the Mammoth's grinder. The molars of the Mammoth generally contain a greater proportion of cement in the intervals of the plates than the Indian Elephant's grinders do. Those in which the plates are more numerous have the enamel less strongly plicated; but in some of the large molar teeth of old Mammoths with the thicker plates, I have seen the enamel as strongly festooned as in the teeth of the Indian Elephant.

The bones of the Mammoth that have hitherto been disinterred present no variations from the characteristic extinct type indicative of distinct species; and it might reasonably have been expected that the lower jaw, for example, with the broad-plated tooth should offer as recognizable differences from that with the narrow-plated teeth, as this does from the lower jaw of the Indian Elephant, if those modifications of the teeth of the Mammoth indicated distinct species. The lower jaw, however, of the ancient British Mammoth has the same distinctive modification of the symphysis as that of the typical Siberian

* Fossils of the South Downs, 4to, 1822, p. 283.

specimen figured by Cuvier, and which is equally presented by that of the Mammoth of Auvergne, figured by the Abbé Croizet *, and by that described by Nesti †.

Both these authors being unacquainted with the intermediate varieties, incline to regard the Mammoth with the thick-plated molars as a distinct species, which V. Meyer in his work cites as the *Elephas meridionalis*. In regard, however, to the proposed distinctive name, I may remark that the variety of molar on which this species is founded occurs not only in England, but in Siberia, and as far north as Eschscholtz Bay.

Most of the molars of the Mammoth from North America are characterized by thinner and more numerous plates than those of England, but the difference is not constant. The Mammoth's molar from the Norfolk coast in the collection of Miss Gurney, which shows nineteen plates in a length of 10 inches, equals several of the molars from North America in the number of the plates. An upper molar of a Mammoth from the gravel of Ballingdon, with a total antero-posterior diameter of 7 inches, consists of twenty plates. Mr. Parkinson cites a molar, now in the Museum of the College of Surgeons, from Wellsbourne in Warwickshire, in which twenty plates exist in a length of $6\frac{1}{2}$ inches; and he figures another molar from the till of Essex, which, in a length of $8\frac{1}{2}$ inches, contains twenty-four plates. On the other hand, the molars of the Mammoths from Eschscholtz Bay, North America, figured by Dr. Buckland, manifest the same kind of variety as those from the English drift; one with a grinding surface $7\frac{1}{2}$ inches long, exhibiting nineteen plates, whilst another in the same extent of grinding surface shows only thirteen plates; both these teeth are from lower jaws, which, like the lower jaw containing the broader-plated tooth described by Prof. Nesti, are precisely similar in form to the other fossil jaws of the Mammoth; they present the same specific differences from the Asiatic Elephant, and offer no modification that can be regarded as specifically distinct from the Mammoth's jaws with narrow-plated molars of Siberia or Ohio.

Mr. Parkinson has figured a Mammoth's molar from Staffordshire, which he deemed to differ from every other that had come to his knowledge in the great thickness of the plates, the smoothness of the sides of the line of enamel, and the appearance of the digitated part of the plates even in the anterior part of the tooth ‡.

This specimen, which is now in the Museum of the College of Surgeons, is the posterior part of a large grinder of an old Mammoth. The superior thickness of the plates arises from the circumstance of the posterior plates being thicker than the anterior ones; these thick plates are more deeply cleft, or their digitated summits are longer, and advance further forward upon the grinding surface of the molar before they are worn down to their common base; they appear also in the specimen to be more advanced than they really are, because of the deficiency of the fore-part of the tooth, which has been broken away. In my opinion this molar has the characters of the thick-plated variety, simply exaggerated from the accidents of age and mutilation abovementioned. It manifests the more constant and characteristic modifications of the *Elephas primigenius* in its relative breadth, and, notwithstanding their thickness, in the number of the plates (nine), which have been exposed by attrition. I have seen a very similar molar of the Mammoth from the Norfolk freshwater deposits in the collection of Mr. Fitch of Norwich.

The abraded summits of the component plates of the Mammoth's molars most commonly present a slight expansion, often lozenge-shaped, at their

* Fossiles du Puy-de-Dome, p. 125. pl. 3. fig. 1.

† Nuov. Giorn. d. Letter. 1825, p. 195.

‡ Organic Remains, iii. p. 344.

centre; the summits of the plates are originally divided, with more regularity, in general, than those in the Indian Elephant, into three digital processes, the middle being usually the broadest and thickest; this character is shown by the middle dilatation when the three digitations are worn down to their common base. Only in one small molar, from the brick-earth at Grays, Essex, in the collection of Mr. Wickham Flower, have I seen the median rhomboidal dilatation, extending, in the abraded plates, so near the end of the section as to approximate the characteristic shape of the plates of the African Elephant's molar; from which, however, the fossil was far removed by its thinner and more numerous plates. The fictitious character of the *Elephas priscus* of Goldfuss and of V. Baer, one of the eight fossil species admitted in the compilation of V. Meyer, has been demonstrated by Cuvier. I have met with no nearer approach to this nominal species among the numerous British Mammoth's grinders that I have examined, than the example just quoted from Grays; I need hardly say that I regard it as another of the numerous varieties to which the molars of the Mammoth were subject.

The clefts that separate the transverse plates are deeper at the sides than at the middle of the tooth in all Mammoths' grinders; hence the ridges of enamel in a much-worn molar are confined to the outer and inner sides of the grinding surface, which is traversed along the middle by a continuous tract of dentine. The layer of enamel extends to this exposed tract, is reflected back upon the opposite side of the lateral cleft, bends round the outer margin of the remaining base of the plate, and is continued into the next fissure, and so on. When the edge of this sinuous coat of enamel is exposed by friction, it describes what Mr. Parkinson has called a "Dædalian line," and he has figured two examples of teeth so worn down in the 'Organic Remains*.' Having noticed the structure in three specimens, Mr. Parkinson conceives it to be characteristic of a distinct species of Mammoth. But the ordinary teeth of the Mammoth, from the unequal vertical extent of their plates above described, must necessarily produce the continuous undulating lateral lines of enamel when worn down to a certain extent. I have seen it only in a few amongst the numerous molars of the Mammoth examined by me, for teeth so worn down are rare. It is well shown in the remains of a very large molar, found in the beach near Happisburg, Norfolk, which on a grinding surface of 4 inches 9 lines in length and 4 inches wide, shows seven dentinal plates worn down to their common uniting base of dentine, along the middle of the surface.

It sometimes happens that the outer and inner margins of a plate, which are always deeper than the middle part, are not on the same transverse line, but one is inclined a little in advance of the other. In this case the abraded crown of the tooth, when worn down to the common middle base of dentine, displays an alternating disposition of the folds of the outer and inner sinuous lines of enamel. This variety affords grounds of the same kind and value for a distinct species of Mammoth as for the two other new species proposed by Mr. Parkinson.

A consideration of the anatomical structure and an extensive comparison of the teeth in question have led me to the conclusion, that whilst some of the supposed specific characters are due to effects of changes produced by age, the others are due to the latitude of variety to which the highly complex molars of the *Elephas primigenius* were subject.

In proof of such variety we have the analogy of existing species: that such variety is the characteristic of a particular part of the enduring remains of the Mammoth, may be inferred from the absence of any corresponding dif-

* Pl. 20. figs. 5 and 7.

ferences in the bones of the Mammoth that have hitherto been found; all of which indicate but one species. And this conclusion harmonizes with the laws of the geographical distribution of the existing species of Elephant.

Throughout the whole continent of Africa but one species of Elephant has been recognized. A second species of Elephant is spread over the south of Asia and some of the adjacent islands; and the results of the more extensive and accurate observations of this species, whilst they make known some well-marked varieties, as the Mooknah, the Dauntelah, &c., founded on modifications of the teeth, establish the unity of species to which those varieties belong. If the observed varieties in the dentition of the Mammoth are to be interpreted, as Parkinson, Nesti, Croizet, V. Meyer and others have done, as evidences of distinct species, we must be prepared to admit not merely three, but six or more distinct species of gigantic Mammoths to have roamed through the primeval swamps and forests of England.

Tusks.—The complete or nearly complete tusks of the *Elephas primigenius* from British strata which have fallen under my observation, possess the same extensive double curvature as the tusks of the great Mammoth in the museum of St. Petersburgh, from the icy cliff at the mouth of the Lena in Siberia, and as those brought to England by Capt. Beechey from Eschscholtz Bay, which have been figured by Dr. Buckland, and are now in the British Museum.

A very perfect specimen, but of moderate size, was lately dug up twelve feet below the surface out of the drift gravel of Cambridge; it measures 5 feet in length and 2 feet 4 inches across the chord of its curve, and it is 11 inches in circumference at the thickest part of its base.

In the collection of Mr. Brown of Stanway there is a fragment of a tusk of the Mammoth, from the freshwater formation at Clacton in Essex, which measures 2 feet in circumference, thus exceeding the size of the largest of the tusks brought home by Capt. Beechey from Eschscholtz Bay.

A very fine tusk of the Mammoth from British strata forms part of the remarkable collection of remains of the Mammoth obtained by the Rev. J. Layton from the drift of the Norfolk coast, near the village of Happisburgh; it was dredged up in 1826, measured 9 feet 6 inches in length, and weighed ninety-seven pounds.

At Knole-sand, near Axminster, about twenty miles from the coast, Sir H. De la Beche obtained a tusk 9 feet 8 inches in length. The finest tusk of a British Mammoth forms part of the rich collection of fossil Mammalian remains obtained from Ilford by the late Joseph Gibson, Esq. of Stratford, Essex; this tusk measured 12 feet 6 inches in length, following the outward curvature.

The smallest Mammoth's tusk which I have seen is in the museum of Mr. Wickham Flower; it is from the drift or till at Ilford, Essex, and has belonged to a very young Mammoth; its length measured along the outer curve is $12\frac{1}{2}$ inches, and the circumference of its base is 4 inches. It has nevertheless been evidently put to use by the young animal, the tip having been obliquely worn.

The small tusk from the Cambridge gravel has not belonged to a young animal, but is fully formed, and it most probably indicates a sexual character, analogous to that in the existing Indian Elephant; the tusks in the female Mammoth, although more developed than they are in the female *Elephas Indicus,* yet being much shorter than in the male Mammoth.

Bones.—Of the bones of the trunk and extremities of the Mammoth, a few examples may be briefly noticed. Of two specimens of the atlas of the Mammoth from the newer Pliocene near Cromer, in the collection of Miss Gurney, the most perfect measures

	In.	Lines.
In breadth	16	6
Breadth of the anterior condyles	7	10
Breadth of the posterior ditto	9	8
In vertical diameter	10	0

A vertebra dentata from the freshwater deposits at Clacton, Essex, twenty feet above high water mark, in the collection of Mr. Brown of Stanway, measures 6 inches 9 lines in transverse diameter, 5 inches in vertical diameter, and has a spinal canal 3 inches in transverse diameter.

A dorsal vertebra, in the same collection, measures in height 1 foot 10 inches, the spinous process being 9 inches high. The transverse diameter of the vertebra is 8 inches 6 lines, that of the spinal canal being 3 inches.

In Mr. Brown's collection is also preserved the os sacrum of a Mammoth from the freshwater formations of Essex. It is of a triangular form; the transverse diameter of the forepart of the body of the first sacral vertebra is 6 inches 6 lines; the diameter of the largest nervous foramen was 2 inches 4 lines.

A scapula, with the spine, the supra-spinal plate and base broken away, from the same formation, shows the characteristic superior breadth of the glenoid articular cavity at its inferior part, and the shortness of the neck of the scapula, which Cuvier has recognized in the scapula of the Siberian Mammoth.

This scapula gave the following dimensions:—

	Ft.	In.
From the glenoid cavity to the inferior angle	1	10
From ditto to the spine	0	4
From the middle of the spine to the lower costa of the scapula	0	8

In a fragment of a Mammoth's scapula from Happisburgh, in the collection of Mr. Fitch of Norwich, the long diameter of the glenoid articulation was 10 inches, its short diameter 4½ inches. The head of the humerus, in the state of an epiphysis, found with the above fragment, measures 10½ inches in its longest diameter. These parts, notwithstanding their dimensions, have belonged to an immature specimen of the Mammoth.

Of the stupendous magnitude to which some individuals, doubtless the old males, of the *Elephas primigenius* arrived, several fossils from the British drift afford striking evidence.

In the noble skeleton of the Mammoth now at St. Petersburgh, which was found entire in the frozen soil of the banks of the Lena, the humerus is 3 feet 4 inches in length; that of the skeleton of the large Indian Elephant (Chuny) which was killed at Exeter Change in 1826, is 2 feet 11 inches in length. In the rich collection of Mammalian remains from the Norfolk coast, belonging to Miss Gurney of North-repps Cottage, near Cromer, there is an entire humerus of the Mammoth which measures 4 feet 5 inches in length.

Subjoined are a few of the dimensions of this enormous bone and of its analogue in the above-mentioned skeleton of the Indian Elephant in the Museum of the College of Surgeons:—

	El. primigenius.			*El. Indicus.*		
	Ft.	In.	Lin.	Ft.	In.	Lin.
Humerus, entire length	4	5	0	2	11	0
Circumference at the middle	2	2	6	1	1	6
Ditto at proximal end	3	5	0	2	8	0
Breadth of distal end	1	2	0	0	10	6
From summit of supinator ridge to end of outer condyle	1	7	0	1	0	6

The humerus of the Mammoth was found in 1836, after a very high tide, partially exposed in the cliff, composed of interblended blue clay and red gravel, near the village of Bacton in Norfolk. The outer crust of the bone is much shattered; it manifests the specific distinction of the humerus of the Mammoth in the relatively shorter proportions of the great supinator ridge, as is shown by the last admeasurement, and the bicipital canal is also relatively narrower.

A portion of a large tibia was obtained from the same bed in 1841; this bone likewise is in Miss Gurney's collection.

A humerus of the Mammoth, wanting the proximal end, from Clacton, Essex, in the collection of Mr. Brown of Stanway, measures 2 feet 10 inches in length, and 15 inches 6 lines in median circumference, showing the thicker proportions as compared with the existing Elephant.

The bones of the fore-arm of the Mammoth from British localities have not offered any characters worthy of notice.

Of those of the fore-foot I have examined some magnificent specimens obtained by Mr. Ball from the brick-loam near Grays, Essex, and which have belonged to a Mammoth as large as that which must have furnished the humerus above described.

The following are the comparative dimensions of some of those bones and of their analogues in the skeleton of Chuny, the great Asiatic Elephant of Exeter Change:—

	El. primigenius.		*El. Asiaticus.*	
	In.	Lin.	In.	Lin.
Os magnum, vertical diameter	4	3	3	0
Middle metacarpal, length	10	0	7	0
Middle breadth of distal end	4	9	3	4

Mr. J. Wickham Flower possesses a fine and perfect specimen of the femur of the Mammoth from the Essex till, which offers the usual characteristic of the extinct species in the relatively narrower posterior interspace between the two condyles and in the thicker shaft. The outer ridge of the femur extends about two-thirds down the bone. The following are some of its dimensions compared with that of the Indian Elephant:—

	El. primigenius.			*El. Indicus.*		
	Ft.	In.	Lin.	Ft.	In.	Lin.
Length	3	4	0	3	6	0
Breadth across proximal end	1	1	6	1	1	0
Breadth across back part of condyles	0	7	6	0	7	0
Circumference of shaft	1	2	6	1	0	0

A femur of the Mammoth, from the drift gravel at Abingdon, is preserved in the Ashmolean Museum. It is remarkable for its fine state of preservation, and exhibits the same character of the extinct species as the foregoing specimen.

The femur of the Mammoth, described by the notable French Surgeon Habicot, in his 'Gigantosteologie, 1613,' as the thigh-bone of Theutobochus, king of the Cimbrians, which was said to be 5 feet in length, indicates a specimen larger than that to which the humerus from Cromer belonged. M. de Blainville is, however, of opinion that the femur in question belonged to a Mastodon.

Strata and Localities.—Of all the extinct Mammalia which have left their fossil remains in British strata, no species was more abundant or more widely distributed than the Mammoth or *Elephas primigenius.*

Wherever the last general geological force has left traces of its operations upon the present surface, in the form of drift or unstratified transported fragments of rock and gravel, and wherever the contemporary or immediately antecedent more tranquil and gradual operations of the sea or fresh waters have formed beds of marl, of brick-earth or loam, there, with few exceptions, have fossil bones or teeth of the Mammoth been discovered.

It would be tedious to specify all the particular localities from which, in collecting the materials for the present report, I have entered records of the existence of the fossil remains of this gigantic quadruped. They are most remarkable for their abundance in the drift along the east coast of England, as at Robin Hood's Bay near Whitby; at Scarborough, at Bridlington, and various places along the shore of Holderness.

Mr. Woodward, in his 'Geology of Norfolk,' supposes that upwards of two thousand grinders of the Mammoth have been dredged up by the fishermen off the little village of Happisburgh in the space of thirteen years. The oyster-bed was discovered here in 1820, and during the first twelve months hundreds of the molar teeth of Mammoths were dredged up. Great quantities of the bones and tusks of the Mammoth are doubtless annually destroyed by the action of the waves of the sea. Remains of the Mammoth are hardly less numerous in Suffolk, especially in the pleistocene beds along the coast and at Stutton; they become more rare in the fluvio-marine crag at Southwold and Thorp. The village of Walton near Harwich is famous for the abundance of these fossils, which lie along the base of the sea-cliffs, mixed with bones of species of Horse, Ox and Deer.

Reference has already been made to other localities in Essex, as Clacton, Grays, Ilford, Copford and Kingsland, where, in the freshwater deposits, the remains of the extinct Elephant occur, associated with the above-mentioned Herbivora, and with more scanty remains of Rhinoceros.

In the valley of the Thames they have been discovered at Sheppey, Woolwich, the Isle of Dogs, Lewisham; in the drift gravel beneath the streets of the metropolis, as in Gray's Inn Lane, twelve feet deep; in Charles Street, near Waterloo Place, thirty feet deep.

Passing westward we encounter Mammoths' remains at Kensington, at Brentford, at Kew, and at Hurley-bottom, Wallingford near Dorchester; in the gravel-pits at Abingdon and Oxford, and at Witham Hill and Bagley Wood*. Bones of the great extinct Elephant again occur in the valley of the Medway, at the Nore, at Chatham, and at Canterbury. On the south coast of England they have been discovered at Brighton, Hove and Worthing; at Lyme Regis and Charmouth; also at Peppering near Arundel, about 80 feet above the present level of the Arun. Passing inland from the south coast we find remains of the Mammoth at Burton and Loders, near Bridport, and near Yeovil in Somerset. At Whitchurch, near Dorchester, Dr. Buckland observes that the remains of the Mammoth lie in gravel above the chalk, and are found in a similar position on Salisbury Plain; they again occur at Box and Newton near Bath, and at Rodborough in Gloucestershire.

Mr. Randall of Stroud has lately acquainted me, that in some recent railway excavations in the neighbourhood of that town, tusks and molar teeth of a Mammoth have been discovered in drift gravel from fourteen to twenty feet below the surface: one of the tusks was recovered in a tolerably perfect state, and measured 9 feet in length; it is in the possession of — Carpenter, Esq., of Gannicox House, near Stroud.

In Worcestershire, on the borders of the Principality, remains of the Mammoth are noticed by Mr. Murchison as occurring in a gravel-pit south of Eastnor Castle. This pit is in the midst of a group of Silurian rocks, and the frag-

* Dr. Kidd's Geological Essays.

ments consist exclusively of those rocks and of the sienite of the adjacent hills, whence Mr. Murchison rightly infers that this extinct species of Elephant formerly ranged over that country. In North Wales Pennant mentions two molar teeth and a tusk found at Holkur, near the mouth of the Vale of Clwyd, in Flintshire, and near Dyserth; they occurred in a bed of drift gravel containing pebbles of lead-ore, which are worked like the analogous stream-works which contain pebbles and sand of tin-ore in Cornwall.

Bones of the Mammoth, with those of the Rhinoceros and Hippopotamus, have been found in coarse gravelly drift with overlying marl and clay in the valley of the Severn, at Fleet's bank near Sandlin. Marine shells occur in the coarse drift, and freshwater shells in the superficial fluviatile deposits.

Mr. Strickland found remains of the Mammoth associated with Hippopotamus, Urus, &c. in the valley of the Avon, in apparently a local fluviatile drift, containing land and freshwater shells: this geologist supposes that after those parts of Worcestershire and Warwickshire had been long under the sea, an elevation of some hundred feet converted them into dry land, and that a river or chain of lakes then descending from the north-east, re-arranged much of the gravel of the great northern glacial drift, disposing it in thin strata and imbedding in it the shells of mollusks and the bones of the extinct quadrupeds.

In the centre of England, Dr. Buckland notices the occurrence of the Mammoth at Trentham in Staffordshire, in different parts of Northamptonshire, and at Newnham and Lawford, near Rugby in Warwickshire; there the Mammoth's bones lay by the side of those of the Rhinoceros and Hyæna.

Mammoth-fossils occur at Middleton in the Yorkshire Wolds, in Brandsburton gravel-hills, and at Overton near York. Remains of the Mammoth, valuable from the condition of the ivory of the tusks, have been discovered at Atwick, near Hornsea, in the county of York.

In Scotland remains of the Mammoth have been found in the drift-clay between Edinburgh and Falkirk, at Kilmuir in Ayreshire.

In Ireland remains of the Mammoth have been found at Maghery in the county of Cavan, and in the drift near Tully-doly, county of Tyrone.

The celebrated cave at Kirkdale concealed remains of Mammoths: the molars here detected were all of small size; very few of them exceed 3 inches in their longest diameter, and they must have belonged to extremely young animals, which had been dragged in by the Hyænas for food with Rhinoceroses, Hippopotamuses, and large Ruminantia.

The molars of the Mammoth which I have hitherto seen from the cave called Kent's Hole near Torquay are of similar young specimens; here they are associated with the Hyæna, the great Cave Tiger, the Cave Bear, &c.: and I entirely accede to Dr. Buckland's explanation, that the bones or bodies of these young Mammoths were dragged into the cave by the Carnivora which coexisted with them.

Quitting the dry land and caves of Great Britain, we find the bed of the German Ocean a most fertile depository of the remains of the *Elephas primigenius*, and they are generally remarkable for their fine state of preservation.

Capt. Byam Martin, the harbour-master at Ramsgate, possesses several well-preserved specimens which have been from time to time brought up by the deep-sea nets of the fishermen, to whom this strange catching of elephants instead of turbot is a matter of disappointment and often of loss. A fine lower jaw of a young Mammoth, in the possession of Mr. G. B. Sowerby, was thus dredged up off the Dogger Bank, and a femur and portion of a large tusk, before described, were raised from 25 fathoms at low water, midway between Yarmouth and the Dutch coast.

Remains of the Mammoth have also been raised in the British Channel from the shoals called Varn and Ridge, which lie midway between Dover and Calais.

These, therefore, with the fishing-banks above mentioned in the German Ocean, seem to be the furthest limits to which it is allowable to trace the remains of lost species in a record of the British Fossil Mammalia.

Indications of the Physical Forces which operated on the unstratified drift containing Bones and Teeth of the Mammoth.

The evidences of an enormous crushing and breaking power are very remarkably exemplified in some of the Mammalian fossils from the 'till' or drift at Walton in Essex. Mr. Brown of Stanway possesses molars of the Mammoth from this locality which have been split vertically and lengthwise, across all the component plates of dentine and enamel; other molars have been so crushed and squeezed that the enamel-plates are shivered in pieces, which are driven into the conglomerate of the different substances, and the fragments of enamel stick out like the bits of glass from the plaster which caps a garden wall.

The ramus of a lower jaw of a Rhinoceros from the drift near the sea-coast of Essex, has been split vertically and lengthwise through all the molars.

A similar condition of some of the mammalian fossil remains, including parts of the Mammoth, discovered by Mr. Stutchbury in a cavernous fissure at Durdham Down near Bristol, has been explained on the hypothesis of considerable relative movement having taken place in the walls of the fissure of the cavern since the deposit of the organic remains; and Mr. Stutchbury adduces, in confirmation of this view, the fact, that a calcareous spar-vein in the vicinity bears undoubted evidence of having been moved and reconstructed.

Other forces than the concussion of rocks by earthquakes seem, however, to have operated in producing the fractures of the teeth and bones in the beds of Essex gravel or drift above adverted to; and I cannot suggest any more probable dynamic, than the action of masses of ice, on the supposition of such being chiefly concerned in the deposition and dispersion of the superficial drift itself.

It is remarkable that the bones and teeth of the Elephant are very rarely rolled or water-worn; the fractured surfaces are generally entire, and sometimes the bones are found, like that in the Ashmolean Museum, in a remarkable state of integrity.

Genus *Mastodon*.

Remains of any species of this extinct genus are extremely rare in Great Britain, and have been hitherto only found in those deposits consisting of sand, shingle, loam and laminated clay, containing an intermixture of the shells of terrestrial, freshwater and marine Mollusca, which extend along the coast of Norfolk and Suffolk, and have been accurately described by Mr. Lyell under the name of the 'Fluvio-marine Crag.'

The first fossil submitted to my examination by Mr. Lyell from this formation, referable to the genus *Mastodon*, was a small part of the left superior maxillary bone containing the second true molar and the remains of the socket of the one anterior to it. The molar was not distinguishable from the corresponding one figured and described by Dr. Kaup in the magnificent remains of the *Mastodon* named by him *longirostris*, which were discovered in a similar fluvio-marine deposit at Epplesheim, Hesse-Darmstadt.

At present, however, I have not been able to appreciate the distinction between the molar teeth of the *Mast. longirostris*, Kaup, and those of the *Mast. angustidens*, Cuvier, the supposed specific distinction being, in fact, afforded by the form and proportion of the lower jaw, which may prove to be a sexual character. As the other molars of the *Mastodon* correspond equally with the *Mast. angustidens* and *Mast. longirostris*, I shall refer them to the species first defined by Cuvier. The British fossil above mentioned was discovered by Mr. J. B. Wigham in 1838, in the fluvio-marine crag at Postwick.

The first representation of any fossil relic of a Mastodon from British strata was given by William Smith: it forms the frontispiece of his original 4to work, 'Strata identified by Organized Fossils,' 1816. The fossil figured is the last molar tooth of the left side of the upper jaw of the *Mast. angustidens*, and was discovered in the fluvio-marine crag at Whitlingham, on the right bank of the Yare, within five miles of Norwich. The crown of the tooth supports five subalternate pairs of mammilloid cones, with a tuberculated posterior ridge: the summits of the first three pairs of cones are worn down by mastication, as in a corresponding molar of the *Mast. angustidens* from Peru, figured by Cuvier in the 'Ossemens Fossiles,' tom. i. Divers Mastodontes, pl. 1. fig. 6: the resemblance is extremely close.

Mr. Wigham likewise discovered a molar tooth of the *Mast. angustidens* in one of the pits excavated in the fluvio-marine crag at Thorpe near Norwich. Here, likewise, another molar tooth of the *Mast. angustidens* was found by Mr. Fitch of Norwich. Detached molars, or fragments of molars of the same species of Mastodon, have been discovered in the same formation, at Horstead by the Rev. J. Gunn, at Bramerton by the late Mr. Woodward, and at Easton cliff between Dunwich and Sizewell by Capt. Alexander, who possesses likewise two specimens from the sea-shore, washed out of the same fluvio-marine crag. Thus the not-long-since questionable occurrence of genuine mastodontal remains in England is placed beyond doubt: they have, hitherto, been exclusively found in a formation referable to the older pliocene division of the tertiary period.

Genus *Rhinoceros*.

The remains of this genus are much more abundant in this country than those of the Mastodon, and are associated in the more superficial strata with the remains of the Mammoth; extending, however, like these, as low as the fluvio-marine crag, but being more commonly found in caverns than are the bones or teeth of the more bulky Mammoth.

Those fossils of the Rhinoceros from British formations, hitherto examined by me and susceptible of satisfactory identification with determinate species, belong to the great two-horned *Rhinoceros tichorhinus* of Cuvier, which is associated in like manner with the Mammoth in Siberia. A few fossils have yielded indications of a second species.

Cuvier says with respect to a portion of the lower jaw discovered in digging a well at Thame in the county of Oxford, and formerly in the Leverian Museum, that, judging from the figure given of it in Douglas's 'Dissertation on the Antiquity of the Earth*,' it seems to belong to the *Rhinoceros leptorhinus*. I have not been able as yet to trace out this specimen, in order to ascertain how far the original would confirm the conjecture of Cuvier.

The molar tooth from the fluvio-marine crag at Bramerton, preserved in the Museum of Natural History at Norwich, has been supposed to belong to the *Rhinoceros leptorhinus*; it bears a closer resemblance to the corresponding

* 4to, 1785.

molar of the *Rh. Schleiermacheri* of Kaup, but a solitary molar tooth is not a very satisfactory ground for pronouncing absolutely of the species of Rhinoceros.

The most complete skeletons of one and the same individual have been found, as might be expected, in caverns or cavernous fissures, where the carcass of the fallen animal has been best protected from external changes and movements of the soil.

Dr. Buckland has recorded one of the most remarkable examples of this kind which was brought to light in the operation of sinking a shaft through solid mountain limestone, in a mining operation for lead-ore near Wirksworth, Derbyshire. A natural cavern was thus laid open, which had become filled to the roof with a confused mass of argillaceous earth and fragments of stone, and had communicated with the surface by a fissure or opening 58 feet deep and 6 feet broad, similarly filled to the top, where the outlet had been concealed by the vegetation. Near the bottom of this fissure, but in the midst of the drift, and raised by many feet of the same material from the floor of the cavern, was found nearly the whole skeleton of a Rhinoceros with the bones almost in their natural juxtaposition: one part of the skull which was recovered showed the rough surface for the front horn; the back part of the skull and one half of the under jaw were detached. All the bones were in a state of high preservation. There were no supernumerary bones to indicate the presence of a second Rhinoceros, but a few remains of Ruminants, apparently of extinct species.

A less proportion, but still a considerable one, of the skeleton of a tichorhine Rhinoceros was discovered by Mr. Whidbey, Engineer of the Plymouth Breakwater, in one of the cavernous fissures of the limestone quarries at Oreston, near Plymouth: the following parts, most of which were determined and have been figured by Mr. Clift, were recovered and preserved:—

Two molar teeth of the upper jaw.
Four do. do. lower jaw.
Portion of the first vertebra, atlas.
Portions of four dorsal vertebræ.
Portions of two caudal vertebræ.
Portions of four ribs.
The symphysial end of an os pubis.
Portions of the right and left scapulæ.
Both articular extremities of the left humerus.
Do. do. right ulna.
Do. do. left radius.
The right os unciforme.
The middle metacarpal bone of the right fore-foot.
A phalanx of the same toe.
Both articular extremities of the right femur.
Part of both extremities of the left femur.
The left patella.
A fragment of the left tibia.
Two portions of metatarsal bones of the right hind-foot.

The state of the epiphyses of the long bones indicate that the animal had not quite reached maturity; but in the same cavernous fissure there was found part of the right humerus of an older individual of the *Rhinoceros tichorhinus*.

The broken bones have suffered from clean fractures; none of them are gnawed or waterworn: the cavern containing them was 15 feet wide, 12 feet high, 45 feet long; it was filled with solid clay.

In similar and adjoining cavernous fissures, detached bones and teeth of the same extinct species of Rhinoceros were found: they were associated in one of the fissures with remains of a large species of Deer and of the *Ursus spelæus*; in another fissure with fossil bones of *Equus, Bos, Cervus, Ursus, Canis, Hyæna,* and *Felis spelæa*: none of the bones exhibit marks of having been gnawed or broken by the teeth of the great cave-haunting Carnivora; but both these and the herbivorous species appear to have perished by accidentally falling into the cavernous fissures before these were filled up by the mud, clay and drift.

The abundant remains of the Rhinoceros discovered in the cave at Kirkdale tell a very different history: they manifest, as Dr. Buckland has demonstrated, abundant evidence of the action of the powerful jaws and teeth of the Hyænas, whose copros and other vestigia prove that ancient cavern to have been their habitual place of refuge. The fossil bones of the Rhinoceroses found in this cavern, as well as in that near Torquay, called Kent's Hole, belonged to animals which inhabited England during the period immediately preceding the deposition of the unstratified drift, and they coexisted with the Mammoth, Hippopotamus, huge Aurochs, Ox and Deer, which likewise became the occasional prey of the Hyænas, whose dwelling-place was thus converted into a kind of charnel-house of the large Herbivora.

The circumstances under which remains of the Rhinoceros have been discovered in the limestone caves of the Mendips, and in those on Durdham Down, lead to similar explanations of their introduction.

The humerus of a Rhinoceros was discovered, associated with remains of the *Hyæna spelæa,* in one of the caves in the carboniferous limestone at Cefn in Denbighshire, at a height of about 100 feet above the present drainage of the country.

Remains of the Rhinoceros were found associated with the entire under jaw of the old Hyæna in the drift at Lawford near Rugby; where likewise, as has already been stated, fossils of the *Elephas primigenius* were found.

With regard to the most instructive remains from this locality, as, for example, the cubitus, Cuvier expressly states that it belongs to the 'espèce cloisonnée*;' and again, with regard to the 'os innominatum,' that it seems to belong to the species with the osseous septum, viz. the *Rhin. tichorhinus*; and with regard to the tibia and the cervical vertebræ, Cuvier confines his observations to their differences as compared with the recent *Rhin. Indicus* (p. 84), or to their want of sufficiently distinguishing characters, p. 76.

Cuvier expressly refers the two skulls of the Rhinoceros discovered in the drift at Newhaven, 15 feet below the surface, to the *Rhin. tichorhinus.*

The teeth of the Rhinoceros from the cave at Kirkdale appear to me not to be distinguishable from those of the *Rhin. tichorhinus.*

The finest and most entire specimens of the tichorhine Rhinoceros from the superficial drift or freshwater formations are in the collection of John Brown, Esq., of Stanway. He possesses the upper part of the skull, 29 inches in length; showing the rough elliptical surfaces for the attachment of the two horns, and demonstrating more clearly than in any other British specimen, the osseous septum of the nose which characterizes the present extinct species. This specimen was discovered at Clacton: associated with it was a part of the lower jaw with the anchylosed symphysis, the length of which is 2 inches 9 lines, and its breadth across the alveoli of the second molar teeth 4 inches. Cuvier seems disposed to admit, from the testimony of Pallas, that the *Rhin. tichorhinus* might have had small incisive teeth in the lower jaw: every trace of their alveoli, if such had existed, have disappeared in the instructive specimen above noticed.

* Ossem. Foss. t. ii. pt. i. p. 80.

A right ramus of the lower jaw of the same species of Rhinoceros, discovered by Mr. Brown in the till at Walton in Essex, indicates, like the molars of the Mammoth described in the former part of this report, the action of enormous and peculiar forces posterior to their deposition in the matrix: it has been split vertically and lengthwise through the seven molar teeth which it contains, and in this clearly fractured state it was discovered when first exposed in the till; and to obviate an unnecessary length in the present report, I shall give the following citations of the discovery of the remains of Rhinoceros in British strata, in a tabular form.

Museum.	*Locality.*	*Stratum.*	*Parts.*
Norwich.	Bramerton.	Fluvio-marine crag.	Molar tooth.
Miss Gurney.	Mundesley.	Lacustrine blue clay.	Portion of lower jaw with three teeth.
Yorkshire.	Bielbecks.	Lacustrine blue clay.	Molar teeth*.
Ld. Enniskillen.	Maidstone.	Beneath the gravel. Pleistocene.	Atlas, and other bones and teeth.
Mr. Flower.	Ilford.	Pleistocene.	Upper molar.
Do.	Grays.	Do.	Lower molar.
Do.	Ilford.	Do.	Femur.
Mr. Bossey.	Wickham, near Woolwich.	Pleistocene.	Upper jaw, and bones.
Brit. Mus.	Drift near Canterbury	———	Molar tooth, described by Grew, Rarities of Gresham College, pl. xix. fig. 3.
Parkinson.	Fox Hill, Gloucestersh.	Drift.	Molar teeth.
Do.	Chatham.	Drift.	Molar teeth.
Mr. Morris.	Ilford.	Pleistocene.	Teeth.
Do.	Erith.	Do.	Teeth and phalanges.
Do.	Grays.	Do.	Teeth and bones.
Do.	Harwich.	Do.	Bones.
Do.	Kingsland.	Do.	Teeth.

Genus *Hippopotamus*.

Remains of this remarkable genus appear to have been first unequivocally determined by Mr. Trimmer† in a pleistocene formation at Brentford, overlying the London clay; they include several tusks, two lower incisors, an entire molar and the fragment of a second, and were discovered after penetrating through nine feet of brick-earth and seven feet of sandy gravel, in a stratum from one foot to nine feet deep of calcareous earth with freshwater shells: here the remains of the Hippopotami were associated with those of the Mammoth and of species of Deer. The locality is forty feet above the present level of the Thames. Six of the Hippopotamuses' tusks lay within an area of 120 yards. These fossils are referred by Cuvier to the extinct species which he has named *Hippopotamus major*.

Mr. Parkinson obtained from the till at Walton, in Essex, the following remains of the Hippopotamus:—a right lower incisor, the upper extremity of a lower canine, an anterior upper molar, and an ultimate lower molar tooth.

Dr. Buckland discovered molar teeth of the Hippopotamus in the Hyæna-cave at Kirkland, whence he infers that this pachyderm, like the Rhinoceros

* The Bielbecks fossils, Elephant, Rhinoceros, Felis, Urus, &c. &c., are all mentioned in Phillips's Geol. of Yorkshire, vol. i. (2nd edition).

† Philosophical Transactions, 1813.

and Elephant, had been the prey of the Hyænas, which inhabited England immediately preceding the formation of the drift.

The entire skull of a Hippopotamus, which was discovered in the drift-gravel below a peat-bog in Lancashire, is figured by Lee in his Natural History of that county.

Amongst the fossils of the Hippopotamus which I have personally examined from British strata, one of the finest is a considerable portion of the lower jaw, now in the museum of Miss Gurney, from the freshwater deposits overlying the fluvio-marine crag near Cromer. It contains six molars on one side, which occupy an alveolar extent of 1 foot The first molar is separated by an interval of 9 lines from the second.

	In.	Lin.
The depth of the jaw at the third molar tooth is	4	9
From the back part of the last socket to the under margin of the descending angular process.	9	0

In the same rich collection there are several detached molar teeth of Hippopotamus from the same formation, a tusk 12 inches in length, and an incisor of the upper jaw; all establishing the identity of the present species with the *Hippopotamus major* of Cuvier, the remains of which occur in the drift of various parts of continental Europe.

In the Yorkshire Museum there is a molar tooth of the *Hippopotamus major*, from Overton near York.

In the Norwich Museum there is a tusk of the *Hippopotamus major*, which was dredged up from the oyster-bank at Happisburgh: it is black and heavy, being penetrated by iron.

Mr. Brown of Stanway possesses a portion of the tusk of the Hippopotamus from the till at Walton in Essex; it is referable to the *Hippopotamus major*: remains of the same extinct species have been found at Grays and Harwich.

Remains of the Hippopotamus have been found in several of the limestone caves in England besides that at Kirkdale; as, for example, at Kent's Hole, Torquay. Several teeth of the Hippopotamus were found, associated with Mammoth, Rhinoceros, Aurochs, Ox, Hyæna, and Bear, in the cavern at Durdham Down, recently described by Mr. Stutchbury.

Genus *Lophiodon*.

Prior to the year 1839, no fossils referable to any member of the Mammalian class had been detected in the eocene formation called the London and plastic clay. A fossil canine tooth brought up from a depth of 160 feet, out of the plastic clay, while sinking a well in the neighbourhood of Maidstone, unequivocally establishes the fact that the genus *Lophiodon* has contributed to the organic remains of that formation. For the opportunity of examining this rare and interesting fossil I am indebted to Mr. Alport, who has recorded the circumstances attending its discovery, with my note of identification, in his interesting work, 'The Antiquities and Natural History of the Town of Maidstone in Kent.' The size of the canine tooth agrees with that in the Lophiodon which Cuvier has called "La grande espèce d'Argenton," rendered by Fischer* *Lophiodon Isselense*, properly *Isselensis*. The matrix yielding the original fossils of this species is a freshwater hard marl, full of the shells of *Planorbis* and *Lymnæa*, with remains of Crocodiles and Trionyces.

The corresponding formation at Binstead in the Isle of Wight belongs to the eocene tertiary period, and has likewise furnished a fossil referable to the genus Lophiodon, and by its size to the *Loph. Isselensis*. It is a median phalanx of the right fore-foot, and was submitted to me as the bone of an Iguanodon. There is, in fact, a considerable general resemblance between the middle phalanges of this great herbivorous reptile and those of the larger hoofed Mammals; but with respect to the fossil in question, the configura-

* Systema Mammalium, p. 413.

tion of the lateral surfaces for the attachment of the ligaments; the production of the inferior border of the distal articulation into a process for the insertion of the flexor tendon; and the greater curvature or portion of a circle described by the distal articular extremity, which indicates a greater extent and freedom of flexion and extension of the toe than the cold-blooded reptiles possess; all prove the fossil to have belonged to the more agile, warmer-blooded and higher organized Pachyderm. This fossil phalanx forms part of the collection of the Marchioness of Hastings.

A fine fragment of the right ramus of the lower jaw, including the two posterior molar teeth, of a large *Lophiodon*, was dredged up from the bottom of the sea between St. Osyth and Harwich on the Essex coast. It is in the possession of Mr. Brown of Stanway.

Genus *Palæotherium*.

Most of the British fossils referable to this genus have been obtained from the freshwater eocene marls at Binstead or Seafield in the Isle of Wight. I am indebted for the opportunity of determining the specimens here recorded from this locality to Mr. S. P. Pratt, F.R.S., and the Rev. Darwin Fox. They are as follows:—

Palæotherium	*magnum* . . .	Antepenultimate molar, upper jaw.
......	*medium* . . .	Posterior molar, lower jaw.
......	Do.	Portion of ditto ditto.
......	Do.	Posterior molar, upper jaw.
......	Do.	Penultimate molar, upper jaw.
......	Do.	Antepenultimate molar, upper jaw.
......	Do.	Anterior spurious molar.
......	Do.	Crown of canine.
......	Do.	Complete incisor.
......	*crassum* . . .	Second molar, right side, lower jaw.
......	*curtum* (?) . .	A molar tooth.
......	*minus*	Portion of the base of the skull.
......	Do.	Right ramus of the lower jaw with six grinders.
......	Do.	Proximal end of the right radius.
......	Do.	Shaft and distal end of right tibia.
......	*minimum* . .	Anterior molar tooth.

A shaft and distal articular end of a humerus, black, heavy and completely mineralized, from the eocene clay at Hordwell Cliff, Hampshire, in the collection of Mr. Wickham Flower, belongs to the genus *Palæotherium*, and agrees in its size and proportions with the humerus of the *Pal. crassum*. Mr. Wickham Flower likewise possesses an inferior molar tooth of a species of *Palæotherium*, corresponding in size with the *Pal. crassum*, from the same stratum and locality.

Genus *Anoplotherium*.

The remains of this genus have hitherto been met with in Great Britain only in the freshwater eocene deposits in the Isle of Wight, associated with quadrupeds of the same extinct genera as those with which the *Anoplotherium* was originally discovered by Cuvier in the eocene gypsum quarries at Montmartre. The British fossils consist of molar teeth referable to the *Anoplotherium commune* and *A. secundarium*.

Genus *Dichobunes*.

The most complete fossil referable to the Anoplotherioid family indicates a species of the subgenus *Dichobunes*, differing from those therein placed by Cuvier, and which I have named *Dich. cervinum**. The fossil consists of the

* Geological Transactions, 2nd Series, vol. iii. p. 451, and iv. p. 44. See also Annals of Philosophy, New Series, 1825, vol. x. p. 360.

posterior half of the left ramus of the lower jaw with the three true molar teeth: it was found in the lowest bed of the freshwater marl at Binstead.

Molar teeth of the same species of *Dichobunes* have been obtained by Mr. Flower from Hordwell Cliff, associated with the *Palæotherium crassum*, and with other lower organized Vertebrate fossils of the Eocene period, as *Crocodilus Spenceri*, *Trionyx*, *Palæophis*, *Lepidosteus*, &c.

Genus *Chœropotamus*.

Cuvier had recognized amongst the fossil fragments extracted from the gypsum at Montmartre, indications of extinct genera different from the *Palæotheria* and *Anoplotheria*, and to one of the rarest and least satisfactorily represented of these he gave the name of *Chœropotamus*. The fossil to be here noticed not only extends, by its association with the *Palæotheria* and *Anoplotheria*, the analogies of the eocene marls of the Isle of Wight with the gypsum beds at Paris, but affords additional information of the osteology and dentition of the extinct genus, which is essential to the determination of its exact affinities. The details of the comparisons illustrating this part of the history of the Chœropotamus are given in my paper in the Geological Transactions*; they show that the extinct Chœropotamus constituted one of the numerous examples in palæontology of lost links in the chain of animated nature, tending in the present case to connect the *Pachydermata* through the Hog-tribe with the plantigrade *Carnivora*.

The fossil in question is the right ramus of the lower jaw, with all the teeth in place except the second premolar and the incisors. It was discovered by the Rev. D. Fox in the Seafield quarry, near Ryde, Isle of Wight.

Genus *Hyracotherium*.

The freshwater eocene marls of the Isle of Wight are much richer in mammalian remains than the contemporaneous formation called the London clay; here, however, one genus, *Lophiodon*, has been found which exists in the eocene gypsum in France, the remains of which also occur in the eocene marls of the Isle of Wight; and the interesting fossil to be described in the present section, although it indicates a genus not, hitherto, found in the older tertiary beds on the continent, demonstrates the extinct quadruped of which it formed part to have been as distinct generically, as the *Anoplotherium* or *Palæotherium*, from any living Mammalia, and to have had the nearest affinity to the *Chœropotamus*.

The fossil in question consists of a mutilated cranium about the size of that of a hare, containing the molar teeth of the upper jaw nearly perfect and the sockets of the canines. It was discovered in the London clay forming the cliffs at Studd Hill, about a mile to the west of Herne Bay, by William Richardson, Esq., who kindly gave me the opportunity and permission of describing it.

The molars are seven in number on each side, and resemble more nearly those of the Chœropotamus than the molars of any other known genus of existing or extinct Mammalia. They consist of four premolars and three true molars.

The first and second premolars, counting from before backwards, have simple subcompressed crowns, surmounted by a single median conical cusp with a small anterior and posterior tubercle at the outer side, and a ridge along the inner side of its base: they are separated from each other by an interspace nearly equal to the antero-posterior diameter of the first premolar, which measures two lines and a half. The second and the remaining molars

* Geol. Trans. Second Series, vol. vi. p. 41.

are in close juxtaposition. The third and fourth premolars present a sudden increase of size and of complexity of the grinding surface, with a corresponding change of form. The plane or transverse section of the crown is subtriangular with the base outwards and nearly straight, the apex inwards and a little forwards, rounded off, to which the anterior and posterior sides converge in curved lines; the grinding surface supports three principal tubercles or cusps, two on the outer and one on the inner side: there are two smaller elevations, with a depression on the summit of each, situated in the middle of the crown, and the whole is surrounded with a ridge, which is developed into a small cusp at the anterior and external angle of the tooth. These teeth form the principal difference between the dentition of the present genus and that of the Chœropotamus, in which the corresponding false molars are relatively smaller and of a simpler construction, having only a single external pyramidal cusp, with an internal transverse ridge or talon at its base. The true molars, three in number on each side, closely correspond in structure with those of the Chœropotamus. They present four principal conical tubercles, situated near the four angles of the quadrilateral grinding surface. Each transverse pair of tubercles is connected at the anterior part of their base by a ridge, which is raised midway into a smaller conical tubercle with an excavated apex. The crown of the tooth is surrounded by a well-marked ridge, which is developed, as in the third and fourth false molars, into a sharp-pointed cusp at the anterior and external angle of the tooth. The hindmost molar is more contracted posteriorly, and its quadrilateral figure less regular than the two preceding molars.

The sockets of the canines or tusks indicate that these teeth were relatively as large as in the Peccari, and that they were directed downwards. The temporal muscles were as well-developed as in the Peccari, the depressed surface for their attachment extending on each side of the cranium as far as the sagittal suture.

The frontal bones are divided by a continuation of the sagittal suture. The nasal suture runs transversely across the cranium parallel with the anterior boundary of the orbits. The lachrymal bone reaches a very little way upon the face. The external angle of the base of the nasal bone, which is of considerable breadth, joins the lachrymal, and separates the superior maxillary from the frontal bone. The anterior margin of the malar bone encroaches a little way upon the face at the anterior boundary of the orbit. The external aperture of the sub-orbital canal is situated about three-fourths of an inch from the anterior boundary of the orbit. The under surface of the palatal processes of the maxillary bones is rugose, as in the Peccari; the portion of the skull, including the intermaxillary bones and the incisive teeth, is unluckily broken off and lost.

That the eye was full and large, is indicated by the size of the optic foramen and the capacity of the orbit, the vertical diameter of which equals 1 inch. The upper part of the cranium, anterior to the sagittal suture, is slightly convex from side to side; its longitudinal contour is nearly straight. The face gradually becomes narrower anteriorly; it is slightly concave at the sides.

The general form of the skull was probably intermediate in character between that of the Hog and the *Hyrax*. The large size of the eye must have given to the physiognomy of the living animal a resemblance to that of the Hare and other timid Rodentia.

Without intending to imply that the present small extinct Pachyderm was more closely allied to the *Hyrax* than as being a member of the same order, and similar in size, I have proposed to call the new genus which it unquestionably indicates, *Hyracotherium*, with the specific name *leporinum*.

In the eocene sand underlying the red crag at Kingston or Kyson in

Suffolk, from which the remains of *Quadrumana* have been obtained*, Mr. Colchester, the discoverer of those remains, has subsequently found the teeth of small mammalian animals, some of which are referable to the genus *Hyracotherium* †.

The teeth from Kyson are three true molars and one of the false molars, all belonging to the upper jaw. The crowns of the true molars present the same shortness in vertical extent, the same inequilateral, four-sided, transverse section, and nearly the same structure, as in *Hyracotherium leporinum*; the grinding surface being raised into four obtuse pyramidal cusps, and surrounded by a well-developed ridge, produced at the anterior and outer angle of the crown into a fifth small cusp.

These teeth are, however, of smaller size, and differ in a point not explicable on the supposition of their having belonged to a smaller individual or variety; for the ridge which passes transversely from the inner to the outer cusp is developed midway into a small crateriform tubercle in the teeth of the *Hyracotherium leporinum*, but preserves its trenchant character in the *Hyrac. Cuniculus*, even in molars which have the larger tubercles worn down.

The premolar in the series of detached teeth from Kyson, which is either the third or fourth, presents the same complication of the crown which distinguishes the *Hyracotherium* from the *Chœropotamus*, but with the same minor modification which distinguishes the true molars of the Kyson species from those of the *Hyrac. leporinum* of Herne Bay; *i. e.* the two ridges which converge from the two outer tubercles towards the internal tubercle are not developed midway into the small excavated tubercle, as in the *Hyrac. leporinum*, but are simple. The disparity of size between the true and false molars appears to be greater in the *Hyrac. Cuniculus* than in the *Hyrac. leporinum*.

This discovery of a second species of the genus *Hyracotherium*, which, hitherto, has been found only in the London clay, tends to place beyond doubt the equivalency of the Kyson sand, underlying the red crag, with the eocene deposits at the estuary of the Thames.

I may add, that the collection of teeth and other small organic fragments from the Kyson clay, which included the molars of the small extinct Pachyderm above described, likewise contained several vertebræ of a serpent, agreeing in every respect, save size, with those of the *Palæophis toliapicus* from the Isle of Sheppey.

Genus *Sus*.

When Cuvier communicated his memoir on the fossil bones of the Hog to the French Academy in 1809, he had met with no specimens from formations less recent than the mosses or turbaries and peat-bogs, and knew not that any had been found in the drift associated with the bones of elephants. He repeats this observation in the edition of the 'Ossemens Fossiles' in 1822; but in the additions to the last volume published in 1825, Cuvier cites the discovery, by M. Bourdet de la Nievre, of a fossil lower jaw of a *Sus*, on the east bank of the lake of Neuchatel, and a fragment of the upper jaw from the cavern at Sandwich, described by Goldfuss.

Dr. Buckland ‡ includes the molar teeth and a large tusk of a boar found in the cave of Hutton in the Mendip Hills, with the true fossils of that receptacle, as the remains of the Mammoth, Spelæan Bear, &c. With respect to cave-bones, however, it is sometimes difficult to produce conviction as to the contemporaneity of extinct and recent species. MM. Croizet and Jobert, in their account of the fossils of Auvergne, give more satisfactory evidence of the coexistence of the genus *Sus* with *Elephas*, *Mastodon*, &c., by describing and figuring well-marked fossils of a species of Hog, which

* See Report of British Association for 1843.

† Geological Transactions, 2nd Series, vol. vi. p. 203.

‡ Reliq. Diluvianæ, p. 59.

they discovered "au milieu de nos couches à ossemens," in the midst of their rich fossiliferous tertiary beds. These observers found, however, that the facial part of their fossil Hog was relatively shorter than in the existing *Sus scrofa*, and they have conceived it to represent a distinct species, viz. the *Sus Avernensis*. Dr. Kaup has described fossils referable to the genus *Sus* from the miocene Epplesheim sand, in which they were associated with fossils of the *Mastodon* and *Dinotherium*.

The oldest fossils of the genus *Sus* from British strata which I have yet seen, are portions of the external incisor of the lower jaw, from fissures in the red crag (probably miocene) of Newbourne near Woodbridge, Suffolk. They were associated with teeth of an extinct *Felis* about the size of a leopard, with those of a bear, and with remains of a large *Cervus*. These mammalian remains were found with the ordinary fossils of the red crag; they had undergone the same process of trituration, and were impregnated with the same colouring matter as the associated bones and teeth of fishes acknowledged to be derived from the regular strata of the red crag. These mammaliferous beds have been proved by Mr. Lyell to be older than the fluvio-marine or Norwich crag, in which remains of the Mastodon, Rhinoceros and Horse have been discovered; and still older than the freshwater Pleistocene deposits from which the remains of the Mammoth, Rhinoceros, &c. are obtained in such abundance.

I have met with some satisfactory instances of the association of fossil remains of a species of Hog with those of the Mammoth in the newer pliocene freshwater formations of England.

In the collection of Mr. Wickham Flower there are good specimens of the teeth of the Hog (molars, and a long and sharp tusk), which were taken from the brick-earth at Grays in Essex, twenty feet below the present surface; these teeth were associated with teeth and bones of a deer, and portions of dark charred wood. Mr. Brown of Stanway has likewise some fossil remains of a young specimen of *Sus* from the freshwater deposits at Grays.

A left upper tusk of a Boar from the Pleistocene beds near Brighton presented a broader longitudinal internal strip of enamel than in those tusks of the Wild Boar of Europe or India which I had for comparison; the longitudinal groove along the unenamelled part was deeper.

These instances of fossil remains of the Hog tribe are, however, very rare. The usual situation of bones of the Hog is that mentioned by Cuvier in peat-bogs. In the Norwich Museum there is the anterior part of the lower jaw of a Hog, which was found four or five feet below the surface in peat-bog upon drift-gravel.

A molar tooth with the upper and lower tusks of a Wild Boar have been found, associated with remains of the Wolf, Beaver, Goat, Roebuck, and large Red-deer in freshwater marl, underlying a bed of peat 10 feet thick, itself covered in some places by the same thickness of shell-marl and alluvium, at Newbury, Berkshire.

In the most recent deposits where the remains of the Hog are usually met with, their identity with the *Sus scrofa* is unequivocal.

I have received from Dr. Richardson a collection of bones, not much altered by time, from a gravel-pit in Lincolnshire, near the boundary between the parishes of Croft and Ikeness; among these were remains of the common Hog.

The tusks and molar teeth of a Boar which were discovered, ten feet below the surface of a peat-bog, near Abingdon, Berkshire, were associated with quantities of hazel-nuts in a blackened or charred state, the whole resting on a layer of sand which was traced extending eighteen feet horizontally.

The anterior part of the left ramus of the jaw of a Hog has been obtained from the drift formation at Kesslingland, Suffolk.

Genus *Equus*.

In England, as on the Continent, remains of the genus *Equus* attest that a species equalling a middle-sized Horse, and one of the size of an Ass, or Zebra, have been the associates of the Mammoth, Rhinoceros, and other extinct quadrupeds whose remains are so generally dispersed in the drift formations, bone-caves, and the newer tertiary deposits. Almost every geological author who has had occasion to notice the mammalian fossils of these recent periods has made mention of such a combination. It has been observed by Dr. Mantell* in the "Elephant-bed" at Brighton; by Mr. Clift† in the cavernous fissures at Oreston; by Dr. Buckland‡ in the ossiferous caves at Kirkdale, in the Mendips and at Paviland; by Mr. Lyell§ in the tertiary deposits on the Norfolk coast; by Col. Hamilton Smith|| in the bone-caves near Torquay; and by Mr. Morris¶ in the mammaliferous deposits in the valley of the Thames, as at Wickham, Ilford, Erith, Grays and Kingsland.

No critical anatomical comparison appears hitherto to have been instituted with regard to the relations of these equine fossils with the existing species. That the fossils vary in size amongst themselves has been more than once noticed; and Dr. Buckland makes a remark** expressive of his suspicion that they belonged to more than one species.

The largest-sized fossil *Equus* from British strata is indicated by a molar tooth, the second of the left side, lower jaw, obtained by Mr. Lyell from a bed of laminated blue clay, with pyrites, eight feet thick, overlying the Norwich crag at Cromer, where it was associated with remains of the *Mammoth*, *Rhinoceros*, *Bos*, *Cervus*, and *Trogontherium*. The antero-posterior diameter of this tooth was 1 inch 4-10ths, equalling that in the largest dray-horses of the present day: other corresponding fossil teeth of *Equus* have measured in the same diameter 1 inch 2-10ths, and 1 inch. The intermediate size, which equals that of the teeth of a horse of between fourteen and fifteen hands high, is the most common one presented by fossils. A middle upper molar tooth from Kent's Hole, Torquay, indicates a horse as large as that from the blue clay at Cromer, but the size of the fossil species would be incorrectly estimated from the analogy of the teeth alone. Although the equine fossils are far from rare, yet they have hitherto in England been always found more or less dispersed or insulated, and no opportunity has occurred of ascertaining the proportions of one and the same individual by the comparison of an entire skeleton with that of the existing species of *Equus*.

The best-authenticated associations of bones of the extremities with jaw and teeth, clearly indicate that the fossil Horse had a coarser and larger head than in the domesticated races; resembling in this respect the Wild Horses of Asia described by Pallas††, and in the same degree approximating the Zebrine and Asinine groups.

It is well known that Cuvier failed to detect any characters in the skeletons of the different existing species of *Equus*, or in the fossil remains of the same genus, by which he could distinguish them; except by their difference of size, which yields but a vague and unsatisfactory approximation.

The second and third molars of both jaws in every fossil specimen of these teeth which I have examined, are narrower transversely in comparison with their antero-posterior diameter than in the existing horse; and a similar character appears to have been recognized by M. H. v. Meyer in the fossil equine teeth from continental localities, since he cites the *Equus angustidens*

* Fossils of the South Downs, 4to. 1822, p. 283.
† Phil.Trans. 1823, p. 86.
‡ Reliquiæ Diluvianæ, pp. 18, 75.
§ Phil. Mag. vol xvi. (1840), pp. 349, 362.
|| Naturalist's Library, Horses, p. 63.
¶ Mag. of Nat. History, 1838, p. 539.
** *Loc. cit.* p. 75, with respect to the equine remains discovered in the Oreston caverns:—"Horses about twelve, of different ages and sizes, as if from more than one species."
†† Zoographia Rosso-Asiatica, tom. i. p. 255.

as a synonym of the species which he subsequently described under the name of *Equus asinus primigenius**.

Amongst the numerous teeth of a species of *Equus*, as large as a horse fourteen and a half hands high, collected from the Oreston cavernous fissures, I have found specimens clearly indicating two distinct species, so far as specific differences may be founded on well-marked modifications of the teeth.

One of these, like the ordinary *Equus fossilis* of the drift and pleistocene formations, most resembles the existing *Equus caballus* in its dental characters; the other, in the more complex and elegant plication of the enamel, and in the bilobed posterior termination of the grinding surface of the last upper molar, more closely approximates the extinct Horse of the miocene period which H. v. Meyer has characterized under the name of the *Equus caballus primigenius*†. The Oreston remains differ, however, from this in the form of the fifth or internal prism of dentine in the upper molars, and in its continuation with the second anterior prism; the fifth prism being oval and insulated in the *Equus primigenius* of V. Meyer.

The Oreston fossil teeth, which in their principal characters manifest so close a relationship with the miocene *Equus primigenius*, differ like the later drift species (*Eq. fossilis*) from the recent Horse, in a greater proportional antero-posterior diameter of the crown of the second upper molar, and also in a less produced anterior angle of the first molar. In neither of the fossil species is the entire tooth so much curved as in the extinct *Equus curvidens*, nob., the contemporary of the Megatherium in South America.

The more common species of fossil Horse from the drift formations and ossiferous caverns, which differs from the existing domestic Horse in its larger proportional head and jaws, resembling in that respect the Wild Horse, but apparently differing in the transversely narrower form of certain molar teeth, may continue to be conveniently indicated by the name of *Equus fossilis*, as Cuvier's "cheval fossile" has been translated by M. H. v. Meyer‡. Of this species, the largest bone of an extremity which I have seen, is a second phalanx from the upper pliocene deposits at Walton-on-Naze, Essex, where it was discovered by Mr. Brown of Stanway; it measures 2 inches 8 lines in extreme breadth, and 2 inches 4 lines in length. The corresponding bones from Oreston are smaller.

The contemporary but distinct species, indicated by the teeth above described from the Oreston caverns, I propose to name *Equus plicidens*, on account of the characteristic plications of the enamel-island in the centre of the molar teeth. I have not yet seen any teeth from British strata having the well-marked characters of those of the *Equus caballus primigenius* of M. H. v. Meyer; but the teeth of the extinct slender-legged Horse, transmitted by Capt. Cautley to the British Museum, are identical with those of the above species from the European miocene.

In the more recent or diluvial formations, a fossil species of *Equus*, smaller than any of the preceding, and about the size of the Wild Ass, is indicated by molar teeth. Of these I may cite a middle molar of the left side of the upper jaw, from the drift overlying the London clay at Chatham; a corresponding molar from the opposite side of the upper jaw, from the drift at Kesslingland in Suffolk; and a fifth molar, left side of lower jaw, from a cavernous fissure at Oreston: all these teeth were in the same fossilized condition as the associated remains of extinct Mammals with which they had clearly been contemporaneous. If we admit the subgeneric separation of those species of the genus *Equus*, Cuv., that have callosities on the fore-legs only, the tail furnished with a terminal brush of long hair, and a longitudinal dorsal line, the last indicated fossil species may be named *Asinus fossilis*.

* Palæologica, p. 80.

† Nova Acta Acad. Nat. Curios. tom. xvi. p. 448.

‡ Palæologica, p. 79.

Several bones of a large Ass were associated with the teeth of the Wild Boar above mentioned, from the marl beneath the peat formation at Newbury, Berks.

I have been favoured with the following notes of the discovery of fossil teeth of a species of *Equus* in Ireland, by John Thompson, Esq. of Belfast. In sinking a well near Downpatrick, in the county of Down, two teeth were found in a stratum of gravel far below the present surface. A tooth was found at Newry under similar circumstances. In the county of Antrim teeth of the Horse have been found four feet below the surface in drift gravel near Belfast, and at the bottom of a turf-bog near Broughshane.

Order Ruminantia.

Family Bovidæ.

Subgenus *Urus**.

Urus priscus, Fossil Aurochs.

The former existence of a gigantic species of this subgenus is unequivocally established by fossil remains of the cranium and horn-cores from various newer tertiary freshwater deposits, especially in Kent and Essex.

One of these specimens was dug out of a stratum of dark-coloured clay below layers of brick-earth and gravel, thirty feet below the surface, at Woolwich; it presents the broad convex forehead, the advanced position of the horns, which rise three inches anterior to the upper occipital ridge, and the obtuse-angled junction of the occipital with the coronal or frontal surface of the skull, all which characters distinguish that part of the skeleton of the Aurochs. The bony cores of the horns extend outwards, with a slight curvature upwards: from the mid-line between their bases to the extremity of one core, in a straight line, measures 2 feet 5 inches.

Another specimen of the fossil cranium of the *Urus*, dug out of a brick-field at Ilford in Essex, presents, with the same essential characters as the preceding, relatively thicker, shorter and more curved horn-cores. This fossil in the shorter horns differs from the preceding, as the American Bison or Ass differs from the European Aurochs; but in the absolute length of the horns it resembles the European Aurochs: it may indicate the female *Urus priscus*.

A broken skull with perfect horn-cores of the *Urus priscus*, discovered by Mr. Strickland in the freshwater drift at Cropthorne, Worcestershire, yields the following dimensions: from tip to tip of the horn-cores, following the anterior curves, 3 feet 8 inches; the same in a straight line, 3 feet 4 inches.

Hitherto no fossil skeleton of the same individual has been discovered in a state of such completeness as to enable the anatomist to ascertain the number of the ribs; a fact which would be of singular importance in determining the relations of the ancient British Aurochs, since the European existing Wild Aurochs has fourteen pairs, and the American Aurochs or Bison has fifteen pairs, whilst all the varieties of Ox and Buffalo have but thirteen pairs of ribs. The number of the true vertebræ is however the same in all the Bovine animals, the costal or dorsal being increased at the expense of the lumbar series in the subgenus *Urus*. Cuvier expresses his opinion of the importance of a precise knowledge of the formations containing remains of the great fossil Aurochs, and regrets that the information on this point is somewhat vague.

The brick-earth from which the two specimens of fossil Aurochs above-cited were found, underlies a layer of sand with pebbles and concretions, containing shells of *Unio* and *Cyclas*; and the remains of both Mammoth and Rhinoceros are unquestionably associated with those of the Aurochs in this formation. The other localities which may be cited, from the less certain character of the

* *Bos Urus*, Linn., but not the *Urus* of the ancients, which Cuvier regards as the true original of our domestic cattle.

proportion of the metacarpal and metatarsal bones—those of the slenderest proportions being referred to the Aurochs,—are Brentford, Wickham, Ilford, Erith, Woolwich, Grays, Whitstable, Gravesend, Copford, and Clacton.

Prof. Phillips has recorded the discovery of the skull with the cores of the horns and the teeth of the great Aurochs at Beilbecks in his 'Geology of Yorkshire,' vol. i. 2nd edition, accompanied by land and freshwater shells, and by remains of the Mammoth, Rhinoceros, Felis, large Horse, large Deer, Wolf, &c.

Subgenus *Bos.*

Bos primigenius, Bojanus. *Bœuf fossile*, Cuvier.

The fortunate discovery of the cranium and horn-cores of this great extinct species in drift and recent tertiary deposits in this country, has enabled me to enter it without hesitation in the list of British Fossil Mammalia, and at the same time to determine its equal antiquity with the Aurochs. The characters of the *Bos primigenius*, as contrasted with the *Urus priscus*, may be advantageously studied in the magnificent specimen of an almost entire skeleton discovered in the drift overlying the London clay at Herne Bay, and now in the collection of Mr. Wickham Flower. The concave forehead with its median longitudinal ridge; the origin of the horns at the extremities of the sharp ridge which divides the frontal from the occipital regions; the acute angle at which these two surfaces of the cranium meet to form the above ridge, all identify this specimen with the *Bos primigenius* described by Cuvier*, Bojanus† and Fremery‡. The cores of the horns bend at first slightly backward and upward, then downward and forward, and finally inward and upward, describing a graceful double curvature: they are tuberculate at the base, moderately impressed by longitudinal grooves, and irregularly perforated: the length of each horn-core along the outer curve is 3 feet 3 inches; the circumference of the core at its base 18 inches 10 lines; the longest diameter of the base $6\frac{1}{2}$ inches; the chord of the arc described by the core is $7\frac{1}{4}$ inches; from the middle line of the forehead to the tip of the core is 2 feet 2 inches.

The length of the lower jaw of this specimen is 1 foot 8 inches; that of the series of molar teeth is 7 inches. All the true vertebræ except the atlas appear to have been recovered, and they include the six remaining cervical vertebræ; thirteen dorsal and six lumbar vertebræ; thus yielding another important character by which this great primeval Ox agrees with the domestic species of the present day. One of the dorsal vertebræ which retains its spinous process measures 1 foot 7 inches in height; a development not greater than might have been expected for the support of the head and horns. One of the scapulæ shows a diseased external surface, ossific inflammation having extended from two depressions in the bone, probably inflicted by the horns of another bull in conflict. The metacarpal bones give additional exemplifications of the true Bovine character of the present extinct species, by their stronger proportions as compared with those of the Aurochs; the length of one being 10 inches, and its circumference $5\frac{1}{2}$ inches.

Mr. Brown of Stanway has recorded his discovery, in a mass of drift-sand overlying the London clay at Clacton on the Essex coast, of the frontal part of the cranium, with the cores of the horns of a large Bovine animal, which, from the direction and degree of curvature of the horns, agrees with the fossil *Bos primigenius*. Each core measured 3 feet along the outer curve from the base to the tip; the chord of the arc of such curve being 8 inches: the diameter of the base was 6 inches in one direction and 5 inches in the other. With these parts of the *Bos primigenius* was found a perfect Mammoth's tooth, 11 inches in length, 8 inches in depth, and 3 inches across the grinding surface.

* Ossem. Foss. iv. p. 150. † Nova Acta Acad. Nat. Cur. xiii. pt. 2.
‡ N. Verh. Koninkl.-Nederlandsch Instituut, Derde Deel, 1831.

The most complete skull of the *Bos primigenius* is that of which the discovery is recorded in the Bath and Cheltenham Gazette for June 26, 1838. The specimen was obtained from the bed of the river Avon, at Melksham, Wilts, and it gives a distinctive character of the present subgenus which could not be deduced from the former specimens on account of their fractured state, viz. the greater length of the frontal region in proportion to its breadth, as compared with that part of the skull of the *Urus*.

Cuvier states with regard to fossil remains of the *Bos primigenius*, "il s'en trouve en Angleterre," apparently on the authority of drawings transmitted to him by Mr. Crow.

Mr. Parkinson* refers his specimens of Bovine fossils dug up in Dumfriesshire to the *Bos primigenius*, but without assigning the grounds for this choice. Cuvier himself devotes a distinct section to the detached fossil bones of the trunk and extremities of the Bovine tribe, expressing his regret at the numerous sources of uncertainty and difficulty attending their determination when unassociated with the skull; whilst he acknowledges the great importance of ascertaining the species of *Bovidæ* to which the bones from each stratum belonged; whether, for example, an Aurochs, an Ox, or a Buffalo had been the companion of the Elephants, Rhinoceroses, &c. which formerly lived in climates of Europe. At the period of the publication of the second edition of the 'Ossemens Fossiles' (1823), no authentic example had been recorded of a cranium of either *Urus priscus* or *Bos primigenius* in strata containing bones of the Mammoth and Rhinoceros; and this statement is repeated in the posthumous edition of the 'Ossemens Fossiles,' 8vo, 1835. The two examples above cited of crania of the *Urus priscus* from newer pliocene freshwater deposits in Kent and Essex, leave no reasonable doubt that a large Aurochs was the associate of the gigantic *Pachyderms*, whose representatives at the present day have the Buffalos for their companion in the tropical swamps and forests. It is true that species of true *Bos* are found wild in the warmer parts of Asia; but no true Aurochs has been discovered within the tropics. The great fossil *Urus* was likewise associated with as large a species of *Bos* in England during the period antecedent to the deposition of the drift.

To determine to which subgenus of *Bovidæ* detached teeth, vertebræ, ribs and other bones of the skeleton belonged, is still attended with much difficulty; such remains, however, sufficiently attest that species as large as the *Urus priscus* and *Bos primigenius* were very extensively distributed throughout England: they have been found in almost all the drift and cave localities, and in the newer tertiary deposits that have been cited in the foregoing part of the present report as yielding the fossil remains of *Elephas*, *Rhinoceros*, *Hyæna* and *Ursus*.

Cuvier† affirms, as the result of his numerous comparisons of the recent and fossil bones of the Bovine animals, that the detached bones resemble each other too much to yield certain specific characters, and that it is necessary to have skulls in order to determine the species. I have however noticed a character in a few fossil metatarsal bones of different sizes from the cavernous fissures at Oreston, and from the freshwater tertiary deposits in Essex, which I have not observed or found recorded in any known existing species of the Bovine family, and which would serve easily and unequivocally to determine the fossil species if once these bones could be found in such connexion or juxtaposition with a cranium as to justify the conclusion that they belonged to the same skeleton with such cranium. At present, unfortunately, this link, essential to a reference of the bones in question to their true subgenus, is wanting, and I can only cite them with a notice of the peculiar character

* Organic Remains, vol. iii. p. 325.

† Ossem. Foss. iv. p. 140.

adverted to, in the hope that some fortunate ulterior discovery may determine whether they belong to a species of Aurochs (*Urus*), or of Ox (*Bos*), or some other subgenus of a Bovine family.

The character in question is an unusual prominence of the inner border of the anterior groove for the extensor tendon which traversed the middle of that surface of the metatarsal bone, bending the groove obliquely outward; it is well shown in a large fossil metatarsal bone, heavily impregnated with iron, from the freshwater formation at Clacton, Essex, and now in the collection of Mr. Brown. I should perhaps have regarded this production of a ridge of bone as due to ossific inflammation, had not two fossil metatarsal bones of a smaller Bovine animal, from the cavernous fissures at Oreston, presented the same character. Both these metatarsals and the larger one from Clacton present more slender proportions than those of the *Bos primigenius*, and in the same degree approach the genus *Urus*.

Bos longifrons.

This species belongs to the subgenus *Bos*, by the form of the forehead and the origin of the horns from the extremities of the upper occipital ridge, but is distinguished from the *Bos primigenius* by its much smaller size, its much shorter horns in proportion to its size, and by its longer and narrower forehead. The horns have a simple curvature forward, and a little downward. Remains of this species were first described by Robert Ball, Esq., Secretary to the Zoological Society of Dublin, in the Proceedings of the Royal Irish Academy for January 1839, as indicating "a variety or race differing very remarkably from any previously described in works with which the author was acquainted." They consisted principally of parts of the skull with the horn-cores, which had been found at considerable depths in bogs in Westmeath, Tyrone and Longford.

One of the specimens from Westmeath gives the following admeasurements:—

	In.	Lines.
Length from the supra-occipital ridge to the nasal bones....	8	0
Breadth of the skull between the roots of the horns	5	5
Breadth of the skull across the middle of the orbits........	6	5
Circumference of base of horn-core	4	3
Length following outer curvature	3	6

In the Hunterian collection there is a frontlet and horn-core of the same species likewise obtained "from a bog in Ireland." Had no other localities for the *Bos longifrons* been known, it might have been held to be of later date than the *Bos primigenius* and *Urus priscus*, of whose existence as the contemporaries of the Mammoth and tichorhine Rhinoceros we have the most satisfactory evidence; I have however been so fortunate as to ascertain, in the survey of the collections of Mammalian Fossils in the Eastern Counties, indubitable specimens of the *Bos longifrons* from freshwater deposits, which are rich in the remains of *Elephas* and *Rhinoceros*.

A specimen of the back part of the cranium and horn-cores in the collection of Mr. Brown of Stanway, obtained by that gentleman from the freshwater deposits at Clacton on the Essex coast, gives the admeasurement from the supra-occipital ridge to the upper margin of the foramen magnum, which is 3 inches 9 lines; the breadth of the skull between the roots of the horns is 5 inches.

A fossil frontlet and horn-cores of the *Bos longifrons*, from a similar freshwater of the newer pliocene period, at Walton, presents the same characters as the specimens from below the Irish bogs, and it is interesting to find that remains of the gigantic Deer (*Megaceros*) are associated with the *Bos longifrons* in the English freshwater deposits, as in the under-bog marls in Ireland.

Remains of the *Bos longifrons* occur in the freshwater drift at Kensington, associated with those of the Mammoth.

The above-described contemporaneous fossil remains of Bovine animals from the British newer tertiary and drift formations clearly establish the important fact, that species of that subgenus, to which belong the domesticated races of the Ox, are as ancient as those of the subgenus *Urus*, now represented by the great Aurochs of the Lithuanian forests; and that the distinguishing characters of that wild race have not needed to be modified to produce the domestic breed, since wild species of *Bos*, as distinct as the domestic Ox now is from the Lithuanian Aurochs, coexisted with a gigantic species of *Urus* during the later tertiary periods of geology.

Genus *Capra*.

Frequent evidence of the smaller ruminating animals is afforded by fossil jaws, teeth and detached bones of the skeleton, and in a few cases by the characteristic appendages of the skull—horns or antlers, which then serve to identify the species or the genus of such fossils.

A fragment of a lower jaw, containing one of the lateral series of six molar teeth, with a part of the skull having the perfect cores of the horns attached, was discovered by Mr. Brown in the newer pliocene deposits at Walton in Essex: these fossils were in the same condition as the bones of the large extinct Mammalia from the same formation. The jaw and teeth agreed in size and configuration with the same parts in the common Goat, and also in the Sheep; and the highly interesting question, which of these had existed contemporaneously with the Mammoth and Rhinoceros, was satisfactorily determined by the cranial fragment: in its shape and size, and especially in the character of the cores of the horns, which were 2 inches in length, subcompressed, pointed, directed upwards, with a slight bend outwards and backwards, it closely agreed with the common Goat (*Capra Hircus*), and with the short-horned female of the Wild Goat (*Capra Ægagrus*), the probable origin of the half-domesticated Goat of Europe.

Whether the *Capra Ægagrus* or the *Capra Ibex* should be regarded as the stock of our domestic breed, has long been a question among naturalists; the weighty argument which may be drawn from the character of the wild species which was contemporary with the *Bos primigenius* and *Bos longifrons*, is shown by the present fossil to be in favour of the *Capra Ægagrus*.

Genus *Cervus*.

Subgenus *Capreolus*.

In the collection of British fossils belonging to Mr. Purdue of Islington, there is an entire left ramus of the lower jaw of a small Ruminant, identical in size and conformation with that of the Roebuck (*Cervus Capreolus*). It was found in a lacustrine deposit of marl, with freshwater shells, below the bed of peat, at Newbury in Berkshire. Antlers of the Roebuck have been found at ten feet deep below the fen-land of Cambridgeshire. The characteristic antlers, with portions of the jaws and teeth of the Roebuck, have been found in the bone-caves in Pembrokeshire, and in the neighbourhood of Stoke-upon-Trent. I have been favoured with specimens from the limestone caverns of the latter locality by Robert Garner, Esq., the author of the 'History of Staffordshire.' Almost the entire skeleton of a small Ruminant, agreeing in size and general characters with the female Roe, has been discovered in the lacustrine formation at Bacton, with the remains of the Trogontherium, Mammoth, &c.

Subgenus *Elaphus*.

A large round-antlered Stag, nearly allied to, if not a variety of, the existing Red Deer (*Cervus Elaphus*, Linn.), was the associate of the great Aurochs, the Mammoth and the Rhinoceros, and its fossil remains have been discovered in almost all those formations and localities which have yielded those of the before-mentioned extinct Mammals.

The oldest stratum yielding evidence of a *Cervus* of the size of the Red Deer, is the Miocene Red Crag at Newbourne, and remains of this species attest its existence through intermediate strata up to the period of the formation of the turbaries and peat-bogs.

Dr. Buckland makes mention of the discovery of an entire skull of a Deer, in the bone-cave at Paviland, as large as a Red Deer, but of a different species. The rounded base of a shed antler, measuring 3 inches in diameter above the brow-antler, and sending forwards the second or bezantler within three inches of the former, indicates a species of the Elaphine group, equalling the *Cervus Megaceros* in the size of the beams of the antler; and therefore, from the known proportions of the body to the antlers in the Red Deer, probably exceeding that great extinct species from the Irish bogs in size, and at least equalling the Wapiti Deer (*Cervus Canadensis*, Brisson). The fossil in question was found in Kent's Hole, where also remains of the *Megaceros* occur.

Subgenus *Dama*.

Antlers slightly palmated, most nearly resembling those of the Fallow Deer (*Cervus Dama*, Linn.), with teeth, portions of jaws and other bones agreeing in size with those parts in the Fallow Deer, have been found in several of the newer tertiary deposits and the bone-caves of England, associated with the usual extinct Mammalia. I received similar remains with the tusks of the Wild Boar from the marl under the peat-moss at Newbury.

The lower jaw of a Deer, about the size of the Fallow, occurs in the pliocene at Bacton.

Subgenus *Megaceros*.

Megaceros Hibernicus.

The most remarkable of the unquestionably extinct species of the Cervine family is that which is commonly called the Irish Elk. The most abundant and the most perfect examples of this noble animal have been furnished by the bogs of Ireland, where they occur below the peat in the lacustrine marl, but the species is by no means peculiar to Ireland; an entire skeleton having been found in the newer pliocene deposits in the Isle of Man, and characteristic portions of the skeleton and antlers in freshwater deposits of a corresponding age, and in some of the bone-caves of England.

Dr. Molyneux*, the original describer of the antlers of the *Megaceros*, points out their distinction from the true Elk, and the true affinities of the extinct species have been more exactly determined by Cuvier and later anatomists.

The rounded beam of the antler expands, sooner than in the true *Dama*, into a broad palm, which sends off all the processes or snags, save one, from its anterior border, in which respect *Megaceros* differs from *Dama* and resembles *Alces*; it differs from the Elk in having one posterior branch or 'spiller,' and more especially in having both brow-antler and bezantler. The Reindeer (*Rangifer*) makes the nearest approach to the *Megaceros* in the large development of the antlers, but the extinct species far surpasses all known *Cervidæ* in the enormous proportions of the antlers as compared with the skull. In the occasional bifurcation of the expanded end of the brow-antler it again approximates the characters of the Reindeer (*Rangifer*), but does not push its affinity to this genus so far as to have antlers developed in both sexes, as Cuvier suspected.

* Philos. Trans. vol. xiv. p. 489.

My friend Col. Hamilton Smith, the founder of the subgeneric divisions of the Linnæan *Cervus*, has referred the gigantic Deer of Ireland to the section *Dama*, or the Fallow Deer*; but the peculiar proportions and modifications of the antlers of the extinct species in question afford as good grounds for a special subgenus for its reception, as those on which the subgenus *Dama* itself has been proposed.

I subjoin the following dimensions of the skull and antlers of a few of the most perfect specimens that have come under my notice:—

	No. 1, ft. in.	No. 2, ft. in.	No. 3, ft. in.
Length of skull	1 7	1 8	1 7
Between the extreme tips of the antlers in a straight line	8 4	8 9	9 2
Length of a single antler, following its curve	5 9	7 3	5 10

The difference in the extent of the interspace between the tips of the antlers depends on their direction and degree of curvature. Dr. Hart states that it is not uncommon to find the fossil antlers 10 feet between the extreme tips; the same interspace between the largest antlers of the true Elk does not exceed 4 feet.

With regard to the skeleton, if the peculiar size and strength of the cervical vertebræ in the male *Megaceros* be excepted, which have a physiological adaptive relation to the enormous weight of the head when the antlers are fully developed, the forms and proportions of all the other bones, and especially those of the nose and of the upper and lower jaws, closely agree with the type of the Fallow and Reindeer.

Prof. Phillips first described the skull of the female *Megaceros*, and showed that, as in the typical Deer, it had no trace of antlers.

I have had the opportunity, through the kindness of the Earl of Enniskillen, of examining three other skulls of the female *Megaceros*. The skull in this sex is chiefly characterized by a longitudinal angular prominence, which rises from the posterior half of the frontal suture, and very much resembles the median prominence, sometimes called the third horn of the Giraffe. An irregular subquadrangular vacancy intervenes between the angular extremities of the frontal, nasal, lachrymal and superior maxillary bones. The roof of each orbit is perforated by a circular foramen, smaller than in the male.

The earliest observations bear testimony to the abundance of the remains of the *Megaceros* in Ireland. In the account given by Molyneux in 1697, three specimens were disinterred from the same bog within the extent of a single acre, at Dardiston in the county of Meath.

The first specimen discovered in England consisted of a skull and antlers from beneath a peat-moss at Cowthorpe, near North Deighton, in the county of York.

Mr. Parkinson refers the beams of two antlers found in the till at Walton in Essex, on account of their large size, to the great Irish Deer, and I have obtained more satisfactory evidence of the *Megaceros* from the same newer pliocene stratum, by inspection of the collection of fossils belonging to Mr. Brown of Stanway, in which is preserved, not only the large round beam, but the characteristic brow-antler and part of the palm, as far as where it has expanded to a breadth of 10 inches. The length of the brow-antler is 5½ inches, but its extremity is broken off.

Mr. Brown has obtained from the same freshwater formation on the Essex coast, the entire lower jaw of the *Megaceros*.

The base of an antler as large as that of the *Megaceros* has been dredged

* Griffith's Translation of Cuvier, vol. iv. p. 87; vol. v. p. 306.

up from the oyster-bed at Happisburgh, already referred to as famous for the numerous teeth of the Mammoth which it has yielded.

Remains of the *Megaceros* found 8½ feet below the surface of a peat-bog at Hilgay, Norfolk, are preserved in the collection of Mr. Flower, of Hunter-street, London. Antlers of the *Megaceros* have been disinterred from the marl or gravel beneath peat-bogs in Lancashire.

The formerly unique skeleton of the *Megaceros* in the Museum of the University of Edinburgh was obtained from a formation in the Isle of Man, which Mr. E. Forbes, Prof. of Botany in King's College, London, informs me is a white marl, with freshwater shells found in detached masses, occupying hollows in the red marl, which, by the proportion of marine shells of the species found in the neighbouring seas, is referable to the newer pliocene period. The cervine fossils have never been met with in the marine or red marls in the Isle of Man, but only in the white marls occupying the freshwater basins of the red marl; and from the position of the beds containing the remains of the *Megaceros*, Prof. Forbes concludes that this gigantic species must have existed posterior to the elevation of the newer pliocene marl, which is probably continuous with the same formation in Lancashire and at the mouth of the Clyde, forming a great plain, extending from Scotland to Cheshire, and now for the most part covered by the sea.

Fragments of the huge antlers and other remains of the *Megaceros* have been discovered in some of the ossiferous caverns in England. A characteristic specimen, now in the British Museum, was obtained by Mr. M'Enery from Kent's Hole; it consists of part of the upper jaw with both series of molar teeth; it precisely corresponds with the same parts in the skull of a *Megaceros* from Ireland. Since, however, other large Ruminants have been introduced into the same cavern, I have compared it with the nearest analogues from that order. The molar teeth and intervening palate are broader transversely in the fossil than in the Ox; the molars differ from those of the Aurochs in the small cusp between the two internal crescents; the posterior palatine foramina, which in the Ox are opposite the interspace of the penultimate and last grinders, and which in the Elk are advanced to opposite the antepenultimate molars, are, in the fossil, opposite the middle of the penultimate molars, as in the *Megaceros*.

Thus the evidence of the former existence of the gigantic extinct Deer, *Megaceros Hibernicus*, though less striking and abundant in England than in Ireland, is complete, and of greater value, inasmuch as it establishes the contemporaneity of that species with the Mammoth, Rhinoceroses, and other extinct Mammalia of the period of the formation of the newest tertiary freshwater fossiliferous strata.

Conclusion.

Collections of Mammalian bones from turbaries and peat-bogs, from the beds of rivers and from gravel-pits, with parts of the human skeleton, and other evidences of their deposition within the human period, have not unfrequently been submitted to my inspection. Such collections have never presented any evidence of an extinct species, and have for the most part included unequivocal remains of the domesticated quadrupeds. Thus a collection of Mammalian bones, transmitted to me by Dr. Richardson of Haslar, from a gravel-pit in Lincolnshire, contained the remains of a Dog, Cat, Hog, Horse, Ass, Ox, and Sheep. A similar collection obtained from the banks of the river Avon, in sinking the foundations of a bridge over the river near the town of Chippenham, included bones of the Dog, Horse, Hog, Ox, Red Deer, and Goat or Sheep.

Such remains have undergone but little change, are not adhesive or absorbent from the loss of the animal matter, nor weighty from the addition of mineral or metallic salts; and are here adduced, though not strictly belonging to a record of fossil Mammalia, to exemplify how readily and exclusively the remains of existing species and varieties of Mammalia, of which so few present themselves in the formations anterior to the human period, are detected when they occur in places of later date.

In fens, turbaries and bogs, the remains of Mammalia indicate recent species, but such, for the most part, as have either existed but are now extirpated in Great Britain, as the Wolf, the Bear, and the Beaver; or which still remain in a wild or domesticated state, as the Fox, the Wild Boar, the primitive short-horned Ox (*Bos longifrons*), the Goat, &c.

In the freshwater marls beneath the bogs, and in similar deposits overlying newer pliocene strata with marine shells, we first meet with extinct species, as the *Cervus Megaceros, Urus priscus*, &c., belonging to genera which continue to be represented in Great Britain or in Europe by existing species. The unstratified drift or 'till,' so widely dispersed over this island, yields evidence of extinct species belonging to genera still represented, but not in Britain or in Europe, by living species; the *Elephas primigenius, Rhinoceros tichorhinus, Hippopotamus major, Hyæna spelæa,* are familiar examples.

Most of the testaceous Mollusks, which lived contemporaneously with these extinct quadrupeds in England, belong to species which still exist in this island; indicating, as Mr. Lyell* has justly observed, that the climate was not so hot as that of the latitudes to which the Elephant, Rhinoceros and Hippopotamus are now confined.

The freshwater deposits, as those discovered by Mr. Brown at Clacton in Essex, and described by Mr. Lyell at Mundesley and other parts of the Norwich coast, which, from the occurrence of a few species of shells distinct from any at present known in a living state, are referable to the newest tertiary epoch, contain similar evidence of extinct species of Mammalia; some belonging to genera, as *Canis, Ursus, Felis, Putorius, Arvicola, Castor, Equus, Bos, Cervus,* still represented by European species, and others to genera, as *Elephas, Rhinoceros, Hippopotamus, Hyæna,* now confined to the warmer parts of Asia and Africa.

The same association of Mammalian fossils in the ossiferous caverns of Great Britain, indicates the period of their introduction to have corresponded with that of the deposition of the remains above alluded to in the newer pliocene strata; in some of the latter, however, as in the lacustrine ligniferous beds near Bacton, on the Norfolk coast, we obtain evidence of extinct subgenera of Insectivora and Rodentia, as the *Palæospalax* and *Trogontherium*.

When we descend to the older pliocene tertiary formations, as the fluvio-marine crag at Whitlingham, Postwick, Thorpe, and Bramerton in Norfolk, remains of the *Mastodon* occur.

The Eocene tertiary formations reveal more numerous extinct Mammalian genera, and more remote than the *Mastodon* from existing types; while the indications of existing genera, as of the *Macacus*, and perhaps *Didelphys*, are very scanty, and such as one might have least expected to meet with in the latitudes of England.

The constancy of the association of particular organic remains with particular geological strata, is most strikingly illustrated by discovering in the Eocene deposits of England the same peculiar extinct Mammalia which had been determined by Cuvier's masterly investigations of the fossil remains from the corresponding formations on the Continent. In addition to *Lophiodon, Palæotherium, Anoplotherium, Dichobunes,* and *Chœropotamus*, only one other extinct *genus* has been discovered in the Eocene strata of Britain, viz. the *Hyracotherium*, and the nearest affinities of this little Pachyderm are to the *Chœropotamus* of the same epoch.

* Principles of Geology, ed. 1835, vol. i. p. 142.

Thus the existing species and genera of mammiferous animals gradually recede from our view, and new and strange forms appear, as we successively reinstate and bring before the mind's eye the animated beings of the more remote tertiary periods of the earth's history.

The most extraordinary feature in the Palæontology of this island is the proof of the high antiquity of the Mammalian class which has been derived from the oolitic slate at Stonesfield in Oxfordshire. If the existing generic types are almost lost when we reach in a retrospective survey the oldest tertiary periods, we might anticipate that the Mammalia of the oolitic epoch would differ as much from the peculiarly eocene generic forms as these do from those which now exist, and we accordingly find such an anticipation fully borne out by the ascertained characters of the *Amphitherium* and *Phascolotherium*—the most ancient Mammalian inhabitants of this planet.

Report on the excavation made at the junction of the Lower New Red Sandstone with the Coal Measures at Collyhurst, near Manchester. By E. W. Binney.

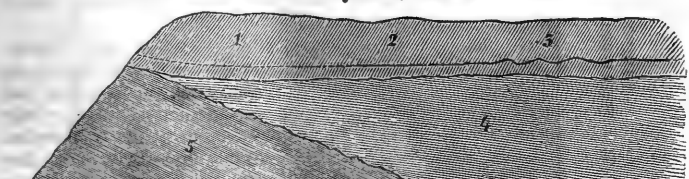
The vicinity of Manchester affords many examples of those great dislocations in the carboniferous strata which took place prior to the deposition of the members of the new red sandstone formation, and into which the waters that deposited the new red sandstone flowed until the hollows formed by such dislocations were at length filled up. A small patch of coal measures, situate on the north-east of the town, known by the name of the Manchester coal field, is an isolated tract entirely surrounded by the new red sandstone. The valley of the Irk cut through the "till," runs nearly in a line with the rise and dip of the strata, and exposes successively the outcrops of the upper new red sandstone, magnesian limestone, and lower new red sandstone, the last-named rock lying upon coal measures 600 yards down in the series. The accompanying section (No. 1) will best show the relative position of the strata (see Section I., p. 242).

As the absolute point of contact between the coal measures and the lower new red sandstone had not been seen, a deep cutting was made at a place called Tinker's Brow, adjoining Mr. Buckley's sand delph, about one mile north-east of the Manchester Exchange. This cutting was visited by many members of the Association at the last meeting, and displayed some interesting facts connected with the till as well as the lower new red sandstone and the coal measures.

In the accompanying section No. 2, a portion of the excavation made in working Mr. Buckley's sand delph, as well as the cutting made on the occasion above mentioned, is shown.

Section II.

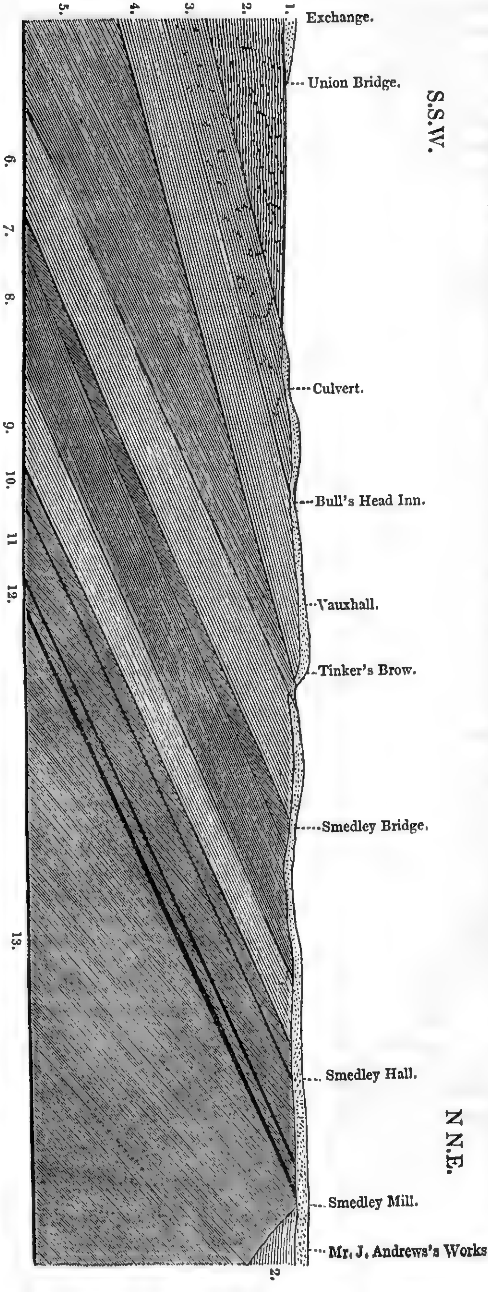
Section of Strata at Collyhurst, near Manchester.



1. Silt (supposed). 2. Till. 3. Contorted Silt.
4. Lower New Red Sandstone dipping at an angle of 18. 5. Coal Measures dipping at an angle of 24.

Section I.

Section (along the Valley of the Irk) from the Manchester Exchange to Mr. J. Andrews's Works, Smedley.



1. Diluvial Gravel.
2, 2. Upper New Red Sandstone.
3. Red Marls with Limestones.
4. Lower New Red Sandstone.
5. Coal Measures.
6. Appleton's Grit Rock.
7. Thin Coal.
8. Shales.
9. Smedley Grit Rock.
10. Coal 12 inches.
11. Coal 18 inches.
12. Coal 3 feet.
13. Coal Measures.

The different beds will be described in the descending order:—

1st, The Till.—Throughout Lancashire this deposit is known in the country by the name of marl, and near towns as brick-clay, and in an economical point of view is the most valuable deposit in the drift series. It is composed of a stiff brown clay, mixed with a little sand, and containing a small proportion of carbonate of lime. On being treated with hydrochloric acid, it effervesces with considerable briskness. The clay when cut down with a knife presents a brown colour, but when allowed to cleave in the open air, which it will do both vertically and horizontally in the act of drying, the sides of the cleavages are coated with a covering of dull blue colour, probably arising from the presence of a small quantity of carbonate of iron. In it are mingled without any order of position blocks of red and light-coloured granites, sienites, porphyries, greenstones, basalts, and various other rocks of igneous origin, clay slates, Silurian rocks, mountain limestones, cherts, millstone grits, all the indurated rocks, ironstones, and coals of the carboniferous series, magnesian limestones, and waterstones (the last-named lying *in situ* amongst the upper red marls), but no other rocks of a more modern date have as yet been found in it. These fragments are of various sizes, from the size of an ordinary pea to blocks of five tons in weight, and lie mingled together without any order of deposition.

The external characters of the boulders in the till are remarkable; some present well-rounded surfaces, others having lost the angles on one or two sides, the edges of the remaining sides are quite sharp; some are scored with striæ and polished, and many are quite angular, as if they had been recently separated from their parent rocks, having scarcely undergone any attrition.

The granites, porphyries, greenstones, and all the hard slate rocks, none of which now occur *in situ* within a less distance than near 100 miles, are for the most part, but certainly not all of them, well-rounded, and many of them are marked with striæ on one or both of their sides. Rocks at present found *in situ* nearer Manchester, such as mountain limestones and cherts, are more angular and less striated and polished than those last mentioned, but the millstone grits, carboniferous strata, magnesian limestones, and waterstones, although some of them are striated, polished and rounded, have generally sharp edges.

Boulders in the till at Collyhurst near the edge of the great fault there are both more numerous and larger than those found in the same deposit in any other place around Manchester. A well-rounded block of greenstone, three tons in weight, was found some years ago in Mr. Buckley's delph, and since the last meeting of the Association at Manchester, a block of millstone grit, of between four and five tons in weight, has been met with in the same place. Three of the sides of this last-named mass have lost their edges, while the remaining one bears evidence of having undergone considerable friction.

It has been stated that the boulders occur in the clay without any distinct lines of deposition, mingled together pell-mell. This is the case at Collyhurst, but still there are at one point distinct lines of a regular deposition from water. At about a yard from the bottom of the till occurs a deposit of fine laminated silt, something resembling the *warp* of our English rivers, with thin layers of fine sand: it is from ten to twelve inches in thickness. This bed is quite free from pebbles, although the till both above and below it is full of them. Generally speaking the silt lies level, but there are several places where it is seen much contorted and twisted without the underlying lower new red sandstone exhibiting any corresponding appearances. The total thickness of the till is twenty-one feet, and it rests on an uneven surface of lower new red sandstone rock, apparently water-worn. No fossil organic remains have as yet, to my knowledge, been found in it at Collyhurst.

2. The lower new red sandstone is composed of a dark red sand, variegated by patches of a yellowish drab colour. The upper part of it is much used for the purpose of iron-moulding, but the lower portion is not fitted for such use, owing to nodules of iron occurring in it. Its grains of sand are well-rounded, and are composed chiefly of white quartz, with some few pieces of jasper, all coloured red by a slight coating of sesquioxide of iron. So uniform in size are the grains, that a pebble as large as a good-sized pea has never yet to my knowledge been found in the rock. The thickness of the rock is full forty yards, but it has never been thoroughly proved by absolute admeasurement. The main dip is to the S.W. at an angle of 16 to 18 degrees, but it has also a considerable inclination to the N.W.

No fossil remains, either of animals or plants, have to my knowledge been found in it.

The upper parts of the rock bear evident marks of erosion by the water which deposited the till. In some places holes two or three feet deep, called by the workmen "posts," are found in the sandstone filled with till, while at other places the surface of the rock is only slightly marked or scooped out.

3. The coal measures consist of a bed of salmon-coloured argillaceous shale, of thirty feet in thickness, containing impressions of *Neuropteris cordata* and many common coal plants. Their position in the carboniferous series is immediately above the Collyhurst sandstone, and under all the coals which have as yet been worked in the Manchester coal field, say about 600 yards below the uppermost of the carboniferous strata at Ardwick. Their dip is 10° east of south, at an angle of 24°. This inclination is not the usual one in the adjoining mines of Mr. Buckley, where it is only 18° to the S.S.W., and must be attributed to the fault which has thrown down the coal measures at the point of junction with the new red sandstone formation, and now forms the trough in which the latter lies. In the collieries above alluded to, the coals in their strike abut against, or as the miners express it, are "cut off" by the new red sandstone.

The chief object for which the excavation was made, was to ascertain the condition of the lower new red sandstone, and the coal measures at the point of contact. The latter were mixed with the loose sand of the former, and the measures, to the depth of three feet, had lost their original laminated structure and become homogeneous, presenting the appearance of drift clay, so that the absolute line of demarcation of one formation from the other could not be determined with any degree of nicety; their colour was a deep red mottled with marks of a dirty yellow; in fact their whole appearance, as well as the red and salmon colours of the underlying strata to a great depth, seemed to show that they had long been exposed to the action of water before they were covered up by the sandstone.

The dip of the two formations does not differ much, that of the coal measures being at an angle of 24° to a little east of south, that of the lower new red sandstone 17° to the S.W., while the usual dip of the former, the Manchester coal field, is 18° to S.S.W., the latter from 5° to 10° to the S.W. The coal measures were partly elevated before the deposition of the new red sandstone formation, but it is evident that the latter have been raised by forces which have subsequently elevated the coal measures, as the similarity of the dip in both strata testifies.

Report on the Fauna of Ireland: Div. Invertebrata. *Drawn up, at the request of the British Association, by* WILLIAM THOMPSON, *Esq., President of the Natural History and Philosophical Society of Belfast.*

Introduction.

IN the former portion of my Report on the Fauna of Ireland, laid before the meeting of the British Association at Glasgow in 1840, the Vertebrata only were included*. In the continuation now presented, are all the native species of Invertebrata—Mollusca, Crustacea, Cirrhipeda, Annelida, Foraminifera, Entozoa, Echinodermata, Acalepha, Zoophyta, Amorphozoa—excepting Insecta and Infusoria, using the former term in its widest sense.

For the whole of the information in some departments I am indebted to others: of a portion undertaken by myself, I have only yet obtained a superficial knowledge. A want of unity will be observable throughout in the treatment of the various subjects, the most obvious point of which to some naturalists will be in the nomenclature:—the first names bestowed on the species, which according to the just rule of priority (see British Association Rules of Nomenclature) should be those used, could only be partially ascertained within the allotted time.

This Report does not embrace so comprehensive a view as I originally contemplated with respect to widely-extended comparisons, and the causes which seem to operate on the distribution of the various classes, &c. of Invertebrata, but as now given, it may afford data to others better qualified to do justice to that subject. It will in its present state only have a value in recording the species indigenous to Ireland, and offering a comparison between them and those of Great Britain, but this is not unimportant with regard even to the general geographical distribution of species. The European Fauna, it need scarcely be observed, could not be perfected without that of Ireland being known, which latter is again especially interesting, in consequence of our island being within its latitude the extreme western limit to which all the species included in it range that are peculiar to the eastern, or in other words, are not found in the western hemisphere.

The Fauna of Ireland, compared with that of Great Britain, exhibits the falling off of species westerly compared with that island, which again on its part (though not treated of here) presents a similar falling off westerly compared with the opposite shore of the continent. An example may be necessary in explanation, and the most striking will be selected, though the subject-matter belong to the former part of this Report. Thus, of the class *Reptilia* there are in

	BELGIUM†.	GREAT BRITAIN.	IRELAND.
Order *Sauria*.			
Lacerta	3 species...	2 species (same as Belg.)...	1 species (same as Brit.).
Anguis.........	1 ,, ...	1 ,, ,, ...	0 ,,

* The species of Vertebrata since added to our catalogue are—
Turdus Whitei, Eyton, Ann. Nat. Hist. vol. xi. p. 78.
Pycnonotus chrysorrhœus, Swains. See present volume.
Cuculus glandarius, Lin., Ann. Nat. Hist. vol. xii. p. 149, and present volume.
Glareola pratincola, Lin. (sp.) See present volume.
Naucrates ductor, Cuv. and Val. See present volume.
The *Lepus Hibernicus* and *L. variabilis* are now proved to be of the same species (see present volume): respecting the animal provisionally called *Mus Hibernicus* no further information has been obtained.

† According to the excellent 'Faune Belge' of De Selys-Longchamps.

	Belgium.		Great Britain.		Ireland.	
Order *Ophidia*.						
Coluber	2	,,	0	,,	0	
Natrix	1	,,	1	,,	(same as Belg.)... 0	
Vipera	2	,,	1	,,	,, ... 0	
Order *Batrachia*.						
Rana	2	,,	1*	,,	,, ... 1	species (same as Brit.).
Bombinator	3	,,	0	,,	0	
Hyla	1	,,	0	,,	0	
Bufo	2	,,	2	,,	(same as Belg.)... 1	,, ,,
Salamandra	1	,,	0	,,	0	
Triton	4	,,	3*	,,	(same as Belg.)... 2	,, ,,
	22		11		5	

It appears therefore that the deficiency of Ireland compared with Great Britain in the *Reptilia*, is much upon the same scale as that of the latter island compared with Belgium.

There is not any island of similar extent to Ireland, and in like manner situated with respect to other lands, with which to compare it. The islands of New Zealand within temperate latitudes in the southern hemisphere may however be mentioned as possessing of indigenous *Mammalia*†, Bats alone, of which one species has been described‡; and no Ophidian reptiles. "Throughout the present Report (to quote from the former portion) it must be borne in mind, that all species found from the Channel Islands in the south, to the Shetland Islands in the north, are included in the fauna of Great Britain, and that within the degrees of latitude over which it extends, Ireland occupies but one-third. Ireland is comprised within four degrees, while the Shetland Islands range nearly six degrees further to the north, and more than two degrees to the south the Channel Islands are situated. The Fauna of Great Britain also extends over ten degrees of longitude, while that of Ireland is limited to half the number."

The *physical geography* and *climate* need not be dwelt on here, as in the case of the Mammalia Terrestria, Aves, and Reptilia, as the *land* Mollusca and Annelides only will be *directly* affected by such influences. The *freshwater* Mollusca, Crustacea, Annelida and Amorphozoa will be affected, but less directly, by the physical geography, taken in connection with the mineralogical structure of the country; as will the *marine* species in some degree, by the nature and quantity of the residuum brought by rivers to the sea. The physical geography of the *bottom* of the sea will have a powerful effect on the marine Invertebrata of all kinds, even greater than that of the dry land on its animals. According to the configuration and depth, to the mineralogical character of the rocks, the vegetation, &c., shall we find particular families, genera, and species. Even where the configuration and depth are similar, the oozy, sandy, gravelly, or rocky bottom, will have each its peculiar animals.

It has not been thought desirable, as in the Report on the Vertebrata, to treat distinctly of every species, as to its being common or rare, &c.; but in-

* *Rana Scotica* and *Triton Bibronii*, of which so little is known, either as to distribution or otherwise, are not enumerated.

† In Mammalia, Belgium has two genera—*Crocidura* and *Cricetus*—not found in Great Britain, in which are four—*Rhinolophus, Talpa, Myoxus, Arvicola*—unknown to Ireland. De Selys-Longchamps believes Belgium to be the most northern limit of the genus *Crocidura*, and states that it is not met with in Holland or Denmark.

‡ The species is *Vespertilio tuberculatus*, Forster. J. E. Gray in Deiffenbach's New Zealand, vol. ii. p. 181. According to the Report of the United States' Exploring Expedition, published in the Edinburgh Philosophical Journal for January 1844;—"none of the Pacific Islands, including New Zealand, contain any native Mammalia except Bats," p. 32.

stead, to leave this to be indicated by the tabular mark of distribution, although it may often prove unsatisfactory. Thus, species which have been found but once on each side of the island are marked as conspicuously under north, east, west and south, as those which are abundant round the coast. But naturalists will not be deceived by this; none will imagine that because *Eulima subulata* exhibits the same number of asterisks as *Rissoa ulvæ*, that the species are equally plentiful; but all will know that the former, though widely distributed, is found in extremely limited numbers, and the latter in abundance where they respectively occur. Nor, was it deemed necessary in so brief a summary, to give the authorities for the occurrence of the various species; but reference is made throughout to the works in which all the details published respecting them will be found.

MOLLUSCA.

Catalogues of the testaceous Mollusca of Ireland, elaborated during the residence of their respective authors in this country, were drawn up about the same time by Capt. Brown and Dr. Turton*, in which they were aided by the collections of Mr. O'Kelly of Dublin, Dr. Thomas Taylor (species contributed by Miss Hutchins of Bantry), Mr. Samuel Wright of Cork, Mrs. Clewlow, Dr. McGee, Dr. McDonnell, and Mr. Templeton of Belfast†. Mr. Templeton, before and after the period of their researches, was silently noting down for future publication all that he could learn upon the subject, but, stationary at his country residence, he was less favourably circumstanced than either of those gentlemen, by whom various parts of the country and coast were visited. Their inquiries, directed to a single branch of natural history, were naturally more productive in that one department than his, whose survey embraced the whole Flora and Fauna of Ireland, for the illustration of which he was diligently collecting materials. To Bryce's 'Tables of Simple Minerals, Rocks and Shells,' found in three of the northern counties, Mr. Hyndman contributed a few hitherto unnoticed species. The native Mollusca, more especially of Youghal and Dublin, have been effectively collected and studied by Mr. Robert Ball, aided by his sister Miss M. Ball; as have those of Limerick and Miltown Malbay, on the western coast, by Mr. Wm. Henry Harvey; those of Cork by Mr. John Humphreys, and those of the northern shores by Mr. Geo. C. Hyndman. A few species of the highest interest from the northern province have been obtained by Dr. J. L. Drummond, as have some from the southern by Dr. Geo. J. Allman. The extensive and beautiful collections of Mr. T. W. Warren and Dr. Farran of Dublin, more particularly of species from the neighbouring coast—the richest in Ireland—have rendered most important aid towards an elucidation of the subject. The Ordnance collection has contributed in so far as the comparatively poor coast investigated could afford. Mrs. Hancock has rendered essential service by assiduously collecting the species of the western shores, at Ballysodare in the county of Sligo, and Bundoran in the county of Donegal, and transmitting them to Belfast, where they came under the inspection of Mr. Hyndman and myself.

* Capt. Brown's memoir was dated from Naas Barracks, Ireland, Aug. 20, 1815, and read before the Wernerian Society of Edinburgh on the 16th of December in that year (see Wern. Mem. vol. ii.). Dr. Turton's appeared in the 'Dublin Examiner, or Monthly Miscellany of Literature, Science and Art,' in July 1816. In the subsequent works of these authors additional Irish species were described: all in the following catalogue that are noticed by them only (i. e. unknown to my correspondents and myself) are marked as on their authority.

† At a subsequent period, the collection of James Rose Clealand, Esq. of Bangor in the county of Down, contributed some interesting species to Sowerby, &c.

Those who have given attention to the Testaceous Mollusca *generally* have hitherto been alluded to. The native land and freshwater species exclusively have been well studied by the Rev. Benj. J. Clarke, Mr. Edward Waller, and the Rev. Thomas Hincks (late of Cork). Several other naturalists and collections might be named, but those enumerated are among the principal.

The species added to our Fauna from the preceding sources and from personal investigation, have been noticed in 'Additions to the Fauna of Ireland,' published in the 'Annals of Natural History' (vol. v. vii. xiii.); in vol. v. a description of *Limneus involutus*, and a contribution on the *Mollusca Nudibranchia* and *Moll. Tunicata* will be found: in vol. vi. is a catalogue of the land and freshwater Mollusca.

Although I had some time since with considerable labour brought together in manuscript all that has been published on the Irish Mollusca, and looked over all the collections possible, I have critically studied a small portion only of the subject. Without the aid therefore of my scientific friends, Mr. Alder of Newcastle-upon-Tyne and Professor Edward Forbes, the Mollusca as a whole could not have been undertaken. In the *Gasteropoda Nudibranchia* and the marine Testaceous tribes their assistance has been most valuable.

Some naturalists will consider the number of British species alluded to in the remarks on the different Orders much under what it should be. This arises from my adoption of the British list, as expurgated by the two distinguished malacologists whose aid has been alluded to. A number of species which have from time to time been introduced without sufficient evidence are omitted; a number more are reduced to mere varieties; and species figured or described in such a manner as not to be understood by the best informed on the subject, are unnoticed.

In the Classes and Orders, Rang's 'Manuel des Mollusques' is chiefly followed.

Class Cephalopoda.

Class Cephalopoda.	Distribution. North.	East.	West.	South.
Sepia officinalis, *Lin.*, *Lam.**	*	*	...	*
,, rupellaria, *Fer.* & *D'Orb.*? (I.)†	*			
Loligo vulgaris, *Lam.*; Sepia loligo, *Lin.*	*	*		
,, sagittata, *Lam.* var.?	...	...	...	*
,, subulata, *Fer.* & *D'Orb.* var. 1. (I.)	*			
,, ,, ,, var. 2.	...	...	...	*
,, media, *Lin.* (sp.)	*	*	...	*
,, Eblanæ, *Ball* (I.)	*	*		
Octopus vulgaris, *Lam.*	*			
Eledone octopodia, *Penn.* (sp.); Sepia octopodia, *Penn.*; Octopus octopodia, *Flem.*	*	*	...	*
,, ——?	*			
Sepiola Rondeletii, *Risso*; Sepia sepiola, *Lin.*	*	*	...	*
Rossia Oweni, *Ball* (I.)	...	*		
,, Jacobi, *Ball* (I.)	...	*		
Spirula australis; Naut. spirula, *Lin.*	*	...	*	*

* It has been considered sufficient throughout this Report simply to indicate the north, east, west and south. The Mollusca of the following localities have been more or less investigated:—*North*, Coasts of Londonderry and Antrim.—*East*, Counties of Antrim, Down, Louth, Dublin, Wicklow.—*West*, Bundoran, co. Donegal; Ballysodare, co. Sligo; Birterbury and Roundstone bays (Dr. Farran); Clifden, Killery and Clew bays, &c., (R. Ball, E. Forbes, G. C. Hyndman, W. T.) in the counties of Mayo and Galway; Miltown Malbay, co. Clare.—*South*, Bantry Bay, Youghal, Cork harbour.

† (I.) throughout the Report denotes species known as Irish, and not as British.

The larger native *Cephalopoda* were noticed in the old county histories, and a few additional species have been briefly indicated by myself in the 'Proceedings of the Zoological Society' (1834), p. 31, and in the 'Annals of Nat. Hist.' vol. v. p. 10. Mr. R. Ball, in bringing before the Royal Irish Academy a notice of a new species of *Loligo* (*L. Eblanæ*) on Nov. 30, 1839, announced the other indigenous species of that genus*, and on the 10th of January, 1842, described before the same Society two new species of *Rossia*, and noticed all the Irish species of *Cephalopoda* of which he was cognisant. These are published in the Proceedings of the Royal Irish Academy of that date. An *Eledone* in my possession, from Belfast bay, though closely allied to *E. octopodia*, seems to be distinct. *Octopus vulgaris* is given on the authority of Templeton only, who remarks that it is "not uncommon," an expression which, taken in connection with the omission of *Eled. octopodia* from his catalogue, leads me to believe that this latter was probably the species meant. If the *Octopus vulgaris* be included, the Irish list contains all the British species excepting *Eledone Aldrovandi*, described by Mr. Macgillivray within the present year in his 'Mollusca of Aberdeenshire.' Five of the Irish *Cephalopoda*—*Sepia rupellaria*, *Loligo subulata*, *L. Eblanæ*, *Rossia Oweni*, *R. Jacobi*—are not known as British species.

Class Pteropoda.

	Distribution. North.	East.	West.	South.
Hyalæa trispinosa, *Cuv.* (Anim. King. by Griff. vol. xii. Mollusca, pl. 3. f. 7.) (I.)	...	...	...	*
? Peracle Flemingi, *Forbes*†; Fusus retroversus, *Flem.*	...	...	*	

No species of this class can be noted with certainty as taken on the coast of Great Britain, it being doubtful whether the *Peracle Flemingi* belong to the *Pteropoda*. This species is only known as Irish from some specimens being found by Mr. Hyndman in shell-sand collected by Mrs. Hancock at Bundoran, on the coast of Donegal, in the summer of 1840. Of *Hyalæa trispinosa* a single example with the contained animal was found by Mr. R. Ball on the beach near Youghal, county of Cork, some years ago, and at the same time with three species of the pedunculated *Cirrhipeda*, (*A. lævis*, *A. sulcata*, *A. fascicularis*) a *Spirula australis*, and an *Ianthina communis*. The *Anatifæ* were attached to the mast of a vessel, and in their "tangled mass" the *Hyalæa* and *Spirula* occurred.

Class Gasteropoda.

Order *Nucleobranchiata*.

	North.	East.	West.	South.
Sagitta Britannica, *Forbes?* Report in present volume	...	...	...	*

This order was first introduced to the British Fauna at the present meeting by Professor E. Forbes, who a few years since obtained examples of it in the Frith of Forth and British Channel in a species which he has named *Sagitta Britannica*. About the same time, Dr. G. J. Allman obtained similar Mollusca (of which he made drawings) on the coast of Cork, but whether they be of the same species is uncertain.

* Proceedings of the Royal Irish Academy, vol. i. p. 362, where *L. Eblanæ* is well figured.

† See his Report in present volume.

Class Gasteropoda.

Order *Nudibranchiata*.

	Distribution. North.	East.	West.	South.
Doris tuberculata, *Cuv.*; D. argo, *Penn.*	*	*	*	*
,, repanda, *Alder & Hancock*, Ann. Nat. Hist. vol. ix. p. 32	...	...	*	
,, bilamellata, *Lin.*; D. verrucosa, *Penn.*	*	*	...	*
,, affinis, *Thomp.* Ann. N. H. vol. v. p. 85 (I.)	*	...	...	*?
,, Ulidiæ, *Thomp.* MSS. (I.)	*			
,, muricata, *Mull.* Thomp. Ann. N. H. vol. v. p. 86	*			
,, aspera, *Ald. & Hanc.* Ann. N. H. vol. ix. p. 32	...	*	...	*?
,, pilosa, *Cuv.*; D. nigricans, *Flem.*	*	*	*?	*
,, sublævis, *Thomp.* Ann. N. H. vol. v. p. 87 (I.)	*			
Goniodoris nodosa, *Mont.* (sp.)*	*	*	*	
var. G. Barvicensis, *Johnst.* (sp.)	...	*	...	*
,, elongata, *Thomp.* Ann. N. H. vol. v. p. 88 (I.)	...	*		
Polycera quadrilineata, *Mull.* (sp.)	*	*	*	*
,, typica, *Thomp.* Ann. N. H. vol. v. p. 92 (I.)	*			
,, ocellata, *Ald. & Hanc.* Ann. N. H. vol. ix. p. 33	...	*		
,, citrina, *Ald.* Ann. N. H. vol. vi. p. 340	...	*		
,, cristata, *Ald.* ,, ,, ,,	...	*		
Euplocamus claviger, *Mull.* (sp.) syn. E. plumosus, Ann. N. H. vol. v. p. 90; E. pulcher, Mag. N. H. vii. p. 490. & Ann. N. H. vii. p. 480.	*			
Tritonia Hombergii, *Cuv.*	...	*		
,, plebeia, *Johns.* Ann. N. H. vol. i. p. 115	...	...	...	*
,, arborescens, *Cuv.* var. T. lactea, Ann. N. H. vol. v. 88	*	*		
Melibœa fragilis, *Forbes*; Malacol. Monensis	...	...	*	*
,, coronata, *Johnst.*; var. M. ornata, *Ald. & Hanc.* Ann. N. H. vol. ix. 34	...	*	...	*
Calliopæa? bifida; Doris bif., *Mont.* Linn. Trans. xi. p. 198. t. 14. f. 3; *Thomp.* Ann. N. H. vol. vii. 480	*			
Eolis papillosa, *Lin.* (sp.)	*	*	*	
,, Zetlandica, *Forbes*, Athenæum, 1839, p. 647	...	...	*	
,, Cuvieri, *Lam.*, *Johnst.* Ann. N. H. vol. i. 120. pl. 3. f. 9–11	...	...	...	*
,, coronata, *Forb.* Athen. *id.*	...	*	...	*
,, pallida, *Ald. & Hanc.* Ann. N. H. vol. ix. p. 35	...	*		
,, alba, ,, ,, ,, vol. xiii. (I.)	...	*		
,, Farrani, ,, ,, ,, ,, (I.)	...	*		
,, Drummondi, *Thomp.*; E. rufibranchialis †, Ann. N. H. vol. v. p. 89 (I.)	*			
,, ——? (I.) ‡	*			
Proctonotus mucroniferus, *Ald. & Hanc.* Ann. N. H. vol. xiii. (I.)	...	*		
Alderia amphibia §, *Allman*, MSS. (I.)	...	...	...	*

Twenty species of *Nudibranchia* were recorded as Irish in 1840 ‖, a number equal to that known to be British in 1828, when Dr. Fleming's 'British Animals'

* "(sp.)" throughout the Report denotes the *specific* name, and it only, to be that of the author quoted.

† Mr. Alder, after an examination of the specimens so designated, considers that they are not the true *E. rufibranchialis*: I have therefore proposed the above name, as from the sketches and minute description of the species in Dr. J. L. Drummond's journal, it has become properly understood.

‡ The species of *Eolis* not named was dredged at Donaghadee in May 1843, by Dr. Drummond, but unfortunately a description was not made out at the time of its capture. The specimen on being submitted to Mr. Alder was stated to be certainly distinct from any of the preceding and to come nearest in form to his *E. concinna* and *E. vittata*, though probably distinct from either of them.

§ *Alderia* is a new genus of Dr. Allman's, as *Proctonotus* is of Messrs. Alder and Hancock.

‖ Annals Nat. Hist. vol. v. p. 84 *et seq.*, and vii. p. 480.

appeared. Since the latter period the British catalogue of species belonging to this beautiful order of Mollusca has been greatly augmented by the labours of Dr. Johnston*, Mr. Edward Forbes†, Mr. Alder‡, and Mr. Hancock, and above all by the two latter gentlemen, who, studying the subject conjointly, have by the very complete and philosophical manner in which their investigations were conducted, thrown the greatest light upon the order *Nudibranchia.*

The number of British species now known is sixty-five§, of which twenty-three have been met with in Ireland; to these latter are to be added eleven species unknown as British, making the number of Irish altogether thirty-four —of these eleven, two constitute new genera, and the remaining nine are, with the exception of the *Doris muricata* of the 'Zoologia Danica,' believed to be new species and are indicated in the preceding catalogue by the initial "(I.)" All of the British genera but two—*Eubranchus* and *Calliopæa* ||— have been procured on the Irish coast; the former is known only from its occurrence in one instance to Mr. Forbes in the Isle of Man; the latter was as a British genus announced for the first time at the present meeting: upon the Irish coast only the new genera *Proctonotus* and *Alderia* have been obtained. The genus *Proctonotus,* together with two new species of *Eolis* and seven species known as British, but not hitherto as Irish ¶, were added to our catalogue by Mr. Alder last autumn during little more than three days' examination of the Dublin coast: within a similar time about equally good results have been obtained by Mr. Hyndman and myself in another locality, Strangford lough; instances which show how much may be done in the *Nudibranchia* within a very limited period. Mr. Alder (who in conjunction with Mr. Hancock is engaged in a monograph of the whole of the British species belonging to this order) having expressed a desire to examine my specimens noticed in the fifth and seventh volumes of the 'Annals of Natural History,' they were at once placed in his hands. This has unexpectedly proved serviceable to myself on the present occasion, as I have had the benefit of his revision of what had been written on the Irish species. Mr. Alder's information on the subject so far surpasses my own, that his opinion has been implicitly followed throughout the preceding catalogue with respect to what are good species, what only varieties, &c.

	Distribution.			
	North.	East.	West.	South.
Class GASTEROPODA. Order *Inferobranchiata.*				
Pleurobranchus plumula; Bulla plum. *Mont.*	...	...	*	
,, ? membranaceus; Lamellaria memb. *Mont.*	...	...	...	*
Are the British species of the order *Inferobranchia.*				
Class GASTEROPODA. Order *Tectibranchiata.*				
Aplysia depilans, *Lin.*	*	*	*	*
,, punctata, *Cuv.*	*	*	*	*

* Annals Nat. Hist. vol. i.

† Annals Nat. Hist. vol. v. p. 102 *et seq.*; *Malacologia Monensis,* Report, British Association, 1839, p. 80.

‡ Annals Nat. Hist. vol. vi. ix. xiii.

§ Messrs. Alder and Hancock have contributed about twenty-five species to this number within the last two or three years.

|| Mr. Alder marks *Doris bifida,* Mont. (which has been obtained in Belfast bay) with doubt, as belonging to this genus. *Montagua* he considers not to be generically distinct from *Eolis.* *Calliopæa dendritica*—the British species—is described in Annals Nat. Hist. for Oct. 1843.

¶ Two of these species, obtained by Dr. Geo. J. Allman on the coast of Cork in August 1842, have been forwarded to me since the preceding was written.

Class Gasteropoda.

Order *Tectibranchiata*.

	Distribution. North.	East.	West.	South.
Bulla lignaria, *Lin.*	*	*	*	*
„ akera, *Mont.*	*	*	*	
„ hydatis, *Lin., Don.*	...	*	...	*
„ Cranchii, *Leach*; B. striata, *Brown.*	*			
„ umbilicata, *Mont.*	...	*	*	*
„ diaphana, *Turt.*; Diaphana pellucida, *Brown,* Illus.	*	*		
„ cylindracea, *Pen., Mont.*	*	*	*	
„ truncata, *Adams., Mont.*	*	*	*	
„ obtusa, *Mont.*	*	*	*	
„ hyalina, *Turt.*	...	*	*	
„ pectinata, *Dillw.*; B. scabra, *Mull.* Zool. Dan.	...	*	*	
Bullæa aperta; Bulla aperta, *Lin., Mont.*	*	*	*	*
„ punctata, *Adams,* (sp.)	...	...	*	
„ catena, *Mont.,* (sp.)	...	...	*	
„ ——— ?* (I.)	...	...	*	

In this order are six British species of *Bulla* (the rarest, four of them being late additions), which have not a place in the Irish catalogue:—one species included only in the latter is believed to be new. *Elysia viridis* (*Aplysia viridis,* Flem., Brit. Anim.), a singular species discovered by Montagu in Devonshire, is the remaining desideratum.

Class Gasteropoda.

Order *Pulmonifera Inoperculata*.

Fam. *Limacidæ*.

	North.	East.	West.	South.
Arion ater, *Lin.,* (sp.)	*	*	*	*
„ hortensis, *Fer.*	*	*	*	
Geomalacus maculosus†, *Allman* (I.)	...	...	...	*
Limax maximus, *Lin.*; L. cinereus, *Drap.*	*	*	*	*
„ arboreus, *Bouchard* ‡	*	*	*	
„ flavus, *Lin., Drap.,*; L. variegatus, *Fer.*	*	*	*	*
„ agrestis, *Lin.*	*	*	*	*
„ carinatus, *Leach*; L. Sowerbii, *Fer.*	...	*		
„ gagates, *Drap.*‡ (I.)	...	*	*	
Testacellus haliotideus, *Fer.*	...	...	...	*

Fam. *Helicidæ*.

	North.	East.	West.	South.
Vitrina pellucida, *Mull.* (sp.)	*	*	*	*
Helix aspersa, *Mull.*	*	*	*	*
„ hortensis, *Lister*	*	*	...	*
„ nemoralis, *Lin.*	*	*	*	*
„ arbustorum, *Lin.*	*	*	...	*
„ pulchella, *Mull.*	*	*	*	*
„ fusca, *Mont.*	*	*	*	*
„ fulva, *Mull.*	*	*	*	*

* The species to which specific names are not applied are unknown as British, and cannot be identified in the many works referred to; all of them have been seen by Mr. Alder, and are unknown to him, as are the few which have been seen by Professor Edw. Forbes to him also. They, together with the species to which manuscript names have been applied, will be described in the Annals of Natural History.

† See Proceedings of Section Zoology and Botany at Cork Meeting, present volume.

‡ See Annals Nat. Hist. vol. vi. p. 204 and 205, and same work, vol. xii. (November 1843) article by Rev. B. J. Clarke, "On the species of *Limax* found in Ireland."

Class Gasteropoda.

Order *Pulmonifera Inoperculata*.

Fam. *Helicidæ*.

Species	North.	East.	West.	South.
Helix aculeata, *Mull.*	*	*	*	*
,, lamellata, *Jeff.*; H. Scarburgensis, *Bean.*	*	*	*	*
,, granulata, *Alder.*; H. hispida, *Mont.*	...	...	*	*
,, hispida, *Mull.*	*	*	*	*
var. sericea, *Mull.*	*			
var. concinna, *Jeff.*	*	*	*	*
,, rufescens, *Penn.*, *Mont.*	*	*	*	*
,, pisana, *Mull.*; H. cingenda, *Mont.*	...	*		
,, virgata, *Mont.*; H. variabilis, *Drap.*	*	*	*	*
,, caperata, *Mont.*; H. striata, *Drap.*	...	*	...	*
,, ericetorum, *Mull.*	*	*	*	*
,, rotundata, *Mull.*; H. radiata, *Mont.*	*	*	*	*
,, umbilicata, *Mont.*; H. rupestris, *Drap.*	*	*	*	*
,, pygmæa, *Drap.*	*	*	*	*
,, alliaria, *Miller*	*	*	*	*
,, cellaria, *Mull.*; H. nitida, *Drap.*	*	*	*	*
,, pura, *Alder.*	*	*	*	*
,, nitidula, *Drap.*	*	*	*	*
,, radiatula, *Alder.*	*	*	*	*
,, lucida, *Drap.*	*	*	...	*
,, excavata, *Bean*	...	...	...	*
,, crystallina, *Drap.*	*	*	*	*
Succinea putris, *Lin.* (sp.); S. amphibia, *Drap.*	*	*	*	*
,, Pfeifferi, *Rossm.*; S. gracilis, *Alder*	*	*	*	*
Bulimus obscurus, *Mull.* (sp.)	*	*		
,, acutus, *Brug.*; B. fasciatus, *Penn.* (sp.)	*	*	*	*
,, lubricus, *Mull.* (sp.)	*	*	*	*
Achatina acicula, *Lam.*	...	*	*	*
Pupa umbilicata, *Drap.*	*	*	*	*
,, Anglica, *Fer.* (sp.)	*	*	*	*
,, marginata, *Drap.*	*	*	*	*
Vertigo edentula, *Drap.* (sp.)	*	*	...	*
,, pygmæa, *Fer.*	*	*	*	*
,, substriata, *Jeff.* Gray's ed. Turt. Man.; V. sexdentata, Turt. Man.	*	*	*	
,, palustris, *Leach*; V. septemdentata, *Fer.*	*	*	...	*
,, pusilla, *Mull.*; Pupa vertigo, *Drap.*	*	*	*	
,, angustior, *Jeff.*; Pupa vertigo, *Mont.*	...	...	*	
Balæa perversa, *Mont.* (sp.)	*	*	*	*
Clausilia bidens, *Mull.* (sp.)	*			
,, nigricans, *Pult.*, *Dillw.* (sp.) C. rugosa, *Drap.*	*	*	*	*

Fam. *Auriculadæ*.

Species	North.	East.	West.	South.
Carychium minimum, *Mull.*	*	*	*	*
Acme fusca, *Boys & Walker* (sp.); Auricula lineata, *Drap.*	*	*	*	*
Auricula denticulata, *Mont.* (sp.); A. personata, *Desh.*, *Lam.*	*	*	...	*
,, bidentata, *Mont.* (sp.); *Fer.*	*	*	*	*
,, alba, *Mont.* (sp.)	*	*	...	*
? ,, fusiformis, *Turt.* (sp.); Vol. fusiformis, *Turt.* Conch. Dict. p. 251	...	*	*	

Fam. *Limneadæ*.

Species	North.	East.	West.	South.
Limneus auricularius, *Mont.* (sp.) } one species, W. T.	...	*	*	*
,, pereger, *Mont.* (sp.) } one species, W. T.	*	*	*	*
,, involutus, *Harvey*, Ann. N. H. vol. v. p. 22. pl. 1 (I.)	...	...	...	*
,, stagnalis, *Mont.* (sp.)	*	*	*	*

Class Gasteropoda.

Order *Pulmonifera Inoperculata.*

Fam. *Limneadæ.*

	North.	East.	West.	South.
Limneus palustris, *Mont.* (sp.)	*	*	*	*
,, truncatulus, *Mull.* (sp.); L. fossarius, *Mont.* (sp.); L. minutus, *Drap.*	*	*	*	*
,, glaber, *Mull.* (sp.); L. elongatus, *Drap.*	...	...	...	*
Amphipeplea glutinosa, *Mull.* (sp.)*	...	*		
Ancylus fluviatilis, *Mull., Drap.*	*	*	*	*
,, lacustris, *Mull., Drap.*	*	*	*	*
Physa fontinalis, *Mont.* (sp.)	*	*	*	*
,, hypnorum, *Mont.* (sp.)	*	*	*	*
Planorbis corneus, *Mont.* (sp.)	...	*		
,, albus, *Mull.*; P. hispidus, *Drap.*	*	*	*	*
,, lævis, *Alder*	*			
,, imbricatus, *Mull.*; P. cristatus, *Drap.*	*	*	*	*
,, carinatus, *Mull.*	*	*	*	*
,, umbilicatus, *Mull.*; P. marginatus, *Drap.*	*	*	*	*
,, vortex, *Mull.*	*	*	*	*
,, spirorbis, *Mull.*; P. vortex, β *Drap.*	*	*	*	*
,, nitidus, *Mull.*; P. fontanus, *Mont.* (sp.); P. complanatus, *Drap.*	*	*	*	*
,, contortus, *Mull.*	*	*	*	*

The *Pulmonifera* of Ireland being treated of very fully in the sixth volume of the Annals of Natural History, it need only be stated here, that the British catalogue contains nineteen species†, which are not in the Irish, and the latter three, which are not in the former. These are *Geomalacus maculosus*, *Limax gagates*, and *Limneus involutus*; the *Limax arboreus*, though unpublished as a British species, is not included, as I have found it to be as common in Ayrshire and the Isle of Wight, as in Ireland. The generic forms which have not a place in the Irish catalogue are *Azeca* and *Segmentina.*

Class Gasteropoda.

Order *Pulmonifera Operculata.*

	North.	East.	West.	South.
Cyclostoma elegans, *Mull.* (sp.)	...	*	*	*

This is the only British species of the Order. A single specimen of the *Cyclostoma productum* is stated by Dr. Turton to have been found by himself in the west of Ireland. Manual Brit. Land, &c. Shells, p. 94.

Class Gasteropoda.

Order *Pectinibranchiata.*

Fam. *Turbinidæ.*

	North.	East.	West.	South.
Eulima polita, *Pult., Mont.* (sp.)	*	*	*	*
,, subulata, *Don.* (sp.); E. bilineata, *Jeff.*	*	*	*	*
,, distorta, *Phil.* (sp.); Melania distorta, *Phil.* (I?) ‡	...	*	*	

* I have been enabled to include the *Amph. glutinosa* since this Report was sent to press, through the kind attention of Mr. Wm. Andrews of Dublin, who favoured me with specimens collected by him last summer in the canal near that city.

† In this number, two species are included which have not been found northward of the Channel Islands; the others are partially distributed in England, and two or three only reach so far north as Scotland.

‡ Mr. Alder thinks *E. polita* of Macgillivray's Aberdeenshire Mollusca may be this species.

Class Gasteropoda.
Order *Pectinibranchiata.*
Fam. *Turbinidæ.*

	Distribution. North.	East.	West.	South.
Eulima ? Jeffreysii. (Gen. Parthenia ?)	...	*		
Parthenia (*Lowe*) decussata, *Mont.* (sp.) ; Turbo, *Mont.*	...	*		
„ elegantissima, *Mont.* (sp.) „ „	...	*	*	*
„ indistincta, *Mont.* (sp.) „ „	...	*	*	
„ fulvocincta, *Thomp.* (sp.) ; Turritella indistincta, *Flem.*	...	*		
„ unica, *Mont.* (sp.) ; Turbo, *Mont.*	...	*	*	
„ nitidissima, *Mont.* (sp.) ; Turbo, *Mont.*	...	*	*	
„ ascaris, *Turt.* (sp.)	...	*	*	
„ glabra, *Leach,* (sp.) ; Alvania glabra, *Leach,* Brit. Mus. *	...	*	*	
Turritella terebra, *Lin.* (sp.)	*	*	*	*
Truncatella Montagui, *Lowe* ; Turbo subtruncata, *Mont.*	...	...	*	
Paludina vivipara, *Mull.* (sp.)	* ?	*	...	* ?
„ tentaculata, *Lin.* (sp.) ; P. impura, *Lam.*	*	*	*	*
Littorina communis ; Turbo littoreus, *Lin.*	*	*	*	*
„ cærulescens, *Lin.* (sp.) ; Turbo petræa, *Mont.*	...	*	*	*
„ rudis, *Mont.* (sp.)	*	*	*	*
„ tenebrosa, *Mont.* (sp.)	...	*	*	*
var ? saxatilis. *Bean*	*	*	*	
„ neritoides, *Lam.* ; Nerita littoralis, *Linn.*	*	*	*	*
Lacuna puteola, *Turt.*	*	*	*	
„ pallidula, *Don., Mont.* (sp.)	*	*	*	*
„ crassior, *Mont.* (sp.)	*	*		
„ quadrifasciata, *Mont.* (sp.) } one Turbo vinctus, *Mont.* ; T. canalis, *Mont.* }	*	*	*	*
Rissoa cimex, *Lin., Don.* (sp.) ; R. crenulata, *Mich.* ?	...	*	*	
„ calathisca, *Laskey* (sp.)	...	...	...	*
„ striatula, *Mont.* (sp.)	...	*	*	
„ punctura, *Mont.* (sp.)†	...	*	...	*
„ Harveyi, *Thomp.* (I.)	...	...	*	
„ costata, *Adams., Mont.* (sp.)	*	*	*	*
„ parva, *Mont.* (sp.)	*	*	*	*
„ rufilabrum, *Leach* ; R. violacea, *Desm.* ?	...	*	*	
„ reticulata, *Mont.* (sp.)	...	*	*	*
„ semicostata, *Mont.* (sp.)	...	*	*	
„ Bryerea, *Mont.* (sp.)‡ (on Brown's authority)	...	*		
„ striata, *Adams., Mont.* (sp.)	*	*	*	*
„ labiosa, *Mont.* (sp.)	*	*	*	*
„ ventricosa, *Mont.* (sp.)	...	*		
„ auricularis, *Mont.* (sp.) (on Turton's authority)	...	*		
„ ? ulvæ, *Penn., Mont.* (sp.)	*	*	*	*
„ ? subumbilicata, *Mont.* (sp.)	*	*	*	
„ interrupta, *Adams., Mont.* (sp.)	*	*	*	
„ rubra, *Adams., Mont.* (sp.)	...	*	*	
„ vitrea, *Mont.* (sp.)	...	*	*	
„ nivosa, *Mont.* (sp.) (on Turton's authority)	...	*		
„ unifasciata, *Mont.* (sp.) (on authority of Turton's Catalogue of Irish Shells)	...	*		
„ rupestris, *Forbes*	*	*	* ?	
„ cingilla, *Mont.* (sp.)	*	*	*	*
„ alba, *Adams.,* (sp.)	...	...	...	*
„ Balliæ, *Thomp.* (I.)	...	...	...	*

* "Possibly a worn *T. ascaris,*" Alder.

† Obtained in a subfossil state by the Rev. D. Landsborough in Ayrshire.

‡ Brown, referring to *Turbo Bryereus* as described and figured by Montagu and Donovan, mentions one specimen having been found at Portmarnock.

Class Gasteropoda.

Order *Pectinibranchiata*.

Fam. *Turbinidæ*.

	Distribution. North.	East.	West.	South.
Rissoa semistriata, *Mont.* (sp.); R. tristriata, *Thomp.* Ann. Nat. Hist. vol. v. p. 98. pl. 2. f. 10	*	...	*	*
„ dispar, *Mont.* (sp.); Turbo ziczac, *Mat. & Rack.* (on authority of Turton and Brown)*	*	*	...	*
„ glabra, *Brown*, Illus.; R.? albella, *Alder*	...	*	*	
„ decussata, *Mont.* (sp.) (on Turton's authority)	...	*		
Odostomia pallida, *Mont.* (sp.)	*	*	*	
„ unidentata, *Mont.* (sp.)	...	*	*	*
„ plicata, *Mont.* (sp.)	*	*	*	
„ spiralis, *Mont.* (sp.)	*	*		
„ interstincta, *Mont.* (sp.)	...	*		
„ cylindrica, *Alder*	...	...	*	
„ obliqua, *Alder*	...	...	*	
——? (I.)	...	...	*	
Skenea depressa, *Mont.* (sp.)	*	*	*	*
„ serpuloides, *Mont.* (sp.) (on Turton's authority)	...	*		
Valvata piscinalis, *Mull.* (sp.) *Lam.*; V. obtusa, *Brard*	*	*	*	*
„ cristata, *Mull.*; V. spirorbis, *Drap.*	*	*	*	*

Fam. *Trochidæ*.

	North.	East.	West.	South.
Neritina fluviatilis, *List.*, *Lin.* (sp.) †	...	*	*	
Phasianella pulla, *Lin.* (sp.)	*	*	*	*
Trochus magus, *Lin.*	*	*	*	*
„ umbilicatus, *Mont.*	*	*	*	*
„ cinerarius, *Penn.*	*	*	*	*
„ littoralis, *Brown* (on Brown's authority)	*	...	*	
„ tumidus, *Mont.*	*	*	*	*
„ papillosus, *Don.*	...	*		
„ ziziphinus, *Lin.*	*	*	*	*
„ exasperatus, *Penn.*	*	*	* ?	
„ millegranus, *Phil.*; T. Martini, *Smith.*	*	*	*	*
„ striatus, *Mont.*; T. Montagui	*	*	...	*
Monodonta crassa, *Mont.* (sp.); Trochus crassus ‡	*	*	*	*
Margarita communis; Turbo margarita, *Mont.*	*	*		
Adeorbis § subcarinatus; Helix subc., *Mont.*	*	*	*	
Ianthina communis, *Lam.*; „ Ianthina, *Lin.*	*	...	*	*
„ exigua, *Sow.*	...	...	*	*
„ nitens, *Menke* (I.)	...	...	*	
Scalaria clathrus, *Penn.* (sp.)	*	*	*	*
„ clathratulus, *Walk.* (sp.)	*	*	*	*
„ Turtoni, *Turt.* (sp.)	*	*	...	*
„ Trevelyana, *Leach*	*	...	...	*
Planaxis lineata, *Da Costa*, (sp.); Bucc. lineatum ‖	...	*	*	

* Noticed by Mr. John Humphreys likewise as found in Cork harbour.

† Turton mentions his finding "several specimens of *Nerita virginea* (Lister, pl. 606. f. 35-37) among the sand at Seafield, in the west of Ireland, on the Atlantic." Conch. Dict. p. 127.

‡ $54\frac{1}{2}°$ lat. most northern locality.

§ *Adeorbis*, Wood (S. V.), Annals Nat. Hist. vol. ix. p. 530.

‖ A specimen of this shell was found by Mr. Warren at Bray near Dublin, and several specimens were obtained by Mr. Hyndman from shell-sand collected at Bundoran, county of Donegal, by Mrs. Hancock. Professor E. Forbes remarks,—"although this shell is called '*Planaxis*' I think it is much more probably a *Nassa*; especially if the Irish specimens be truly native."

Class Gasteropoda.

Order *Pectinibranchiata*.

Fam. *Cerithiadæ*.

	Distribution. North.	East.	West.	South.
Cerithium Pennantii, *Thomp.*; Ann. N. H. vol. v. p. 12; Turbo tubercularis, *Penn.*; Murex fuscatus, *Mont.*	...	...	...	*
,, tubercularis, *Mont.* (sp.)	*	...	*	*
,, reticulatum, *Mont.* (sp.); C. lima, *Lam.*	*	*	*	
,, costatum, *Don.*, *Mont.* (sp.)*	...	...	...	*
Triphoris adversus, *Mont.* (sp.); Murex adv., *Mont.*; Terebra perversa, *Flem.*	...	...	*	

Fam. *Buccinidæ*†.

	North.	East.	West.	South.
Nassa reticulata, *Lin.* (sp.)	*	*	*	*
,, macula, *Mont.* (sp.); N. incrassata	*	*	*	*
,, ambigua, *Pult.*, *Mont.* (sp.)‡	...	*	...	*
Purpura lapillus, *Lin.* (sp.)	*	*	*	*
Monoceros hepaticus, *Mont.* (sp.) (on the authority of Brown & Turton)	*	*		
Buccinum undatum, *Lin.*	*	*	*	*
,, var. B. carinatum, *Turt.*	...	*	...	*
,, Humphreysianum, *Bennet* (I.)§	...	*	...	*
,, fusiforme, *Brod.* Zool. Journ. v. p. 44. t. 3. f. 3. (I.)	...	...	...	*
,, ovum, *Turt.*	...	...	...	*
,, —— ? (I.)	...	...	*	
Fusus antiquus, *Lin.* (sp.); F. despectus, *Lin.*	*	*	...	*
,, corneus, *Lin.* (sp.); Bucc. angustior, *Lister* var. ? F. fenestratus, *Turt.* Mag. N. H. vol. viii. (*E. Forbes*)	*	*	...	*
,, muricatus, *Mont.* (sp.)	*	*	...	*
,, Barvicensis, *Johnst.*	*?			
,, Banffius, *Don.*, *Mont.* (sp.)	*	*	*	*
Pleurotoma Boothii, *Smith*, (sp.) Wern. Mem. vol. viii.	...	*		
,, turricula, *Mont.* (sp.)	*	*	*	*
,, costata, *Penn.*, *Mont.* (sp.)	...	*	*	*
,, septangularis, *Mont.* (sp.)	*	*	*	*
,, attenuata, *Mont.* (sp.)	*	*	*	*
,, nebula, *Mont.* (sp.)	*	*	...	*
,, rufa, *Mont.* (sp.); Murex chordula, *Turt.* Conch. Dict. p. 94. young?	...	*	...	*
,, linearis, *Mont.* (sp.)	*	*	*	
,, purpurea, *Mont.* (sp.)	*	*	*	
,, gracilis, *Mont.* (sp.)	...	*		
,, sinuosa, *Mont.* (sp.) (on Turton's authority)	...	*		
,, Trevellyanum, *Turt.*, Mag. N. H. vol. viii.	...	*		
,, —— ? —— (I.)	*			
,, —— ? —— (I.)	...	...	*	
,, —— ? —— (I.)	...	*		
Triton erinaceus, *Penn.* (sp.)	*	*	*	*
Aporrhais pes-pelecani, *Lin.* (sp.)	*	*	*	*

* This is considered by some naturalists as a doubtful Irish species. Dillwyn was the first to notice it, and the locality he gave was Bantry bay. I have seen specimens which were said to be from this locality, and others stated to be from the Waterford coast, but by whom collected I could not learn with certainty.

† *Pyrula carica.* Turton was imposed on with respect to this shell having been found in the county of Down coast.

‡ Noticed by Turton as found at Portmarnock (Conch. Dict. p. 16), and by Mr. John Humphreys (in a MS. catalogue) as obtained in Cork harbour.

§ *B. Anglicanum*, made synonymous with this in Flem. Brit. Anim., is considered a distinct species by Mr. Alder, to whom *B. Humphreysianum* is unknown as British.

Class Gasteropoda.

Order *Pectinibranchiata.*

Fam. *Involutæ.*

Species	Distribution. North.	East.	West.	South.
Cypræa Europæa, *Mont.*	*	*	*	*
Erato lævis, *Don.* (sp.); Marginella voluta	*	...	*	*
Tornatella fasciata, *Lam.*; T. tornatilis	*	*	*	*

Fam. *Sigaretidæ.*

Species	North.	East.	West.	South.
Sigaretus perspicuus, *Lin.* (sp.); Bulla haliotidea, *Mont.*	*	*	*	*
,, tentaculatus ; Lamellaria tent. *Mont.*, Linn. Trans. xi.	*			
Velutina lævigata, *Lin.* (sp.)	*	*	*	*
,, otis, *Turt.*	...	...	*	

Fam. *Naticidæ.*

Species	North.	East.	West.	South.
Natica monilifera, *Lam.*; N. glaucina, *British authors*	*	*	*	*
,, Alderi, *Forbes*; N. canrena, *Mont.*	*	*	*	*
,, ——? Ann. N. H. vol. v. p. 99. "var. N. Alderi?" Mr. Alder in litt.	...	...	...	*
,, sulcata, *Turt.* (sp.) ,, glabrissima, *Brown* (sp.) Irish Test. Wern. Mem. vol. ii. p. 532. pl. 24. f. 12.—doubtful species	...	*		
,, nitida, *Don.* (sp.); Ner. mammilla, *Turt.* (on Turton's authority)	...	*		

Of about 160 species of British *Pectinibranchia*, 35 are unknown as Irish; they are the rarest species, and the greater number of them have been met with only in a single locality—not one is of common occurrence. About 12 species obtained in Ireland have not a place in the British catalogue. The British genera unknown as Irish, are *Turbo**, *Delphinula*, *Stylina*, Flem., *Volva* (*Ovula*?), *Volvaria*, *Dolium*, *Terebra*†, and *Assiminea.*

Class Gasteropoda.

Order *Scutibranchiata.*

Species	North.	East.	West.	South.
Haliotis tuberculata, *Lin.*‡	*	*		
Calyptræa Sinensis; Patella, *Lin.*	...	*		
Capulus Ungaricus; ,, ,,	*	*	...	*
,, ? antiquatus; ,, ,,	*	*		
,, militaris; ,, *Mont.*	...	*	...	*
Fissurella græca; ,, *Lin.*; F. apertura, young	*	*	*	*
Emarginula fissura; ,, ,,	*	*	*	*
Lottia virginea, *Mull.* (sp.); Patella parva, *Mont.* syn. L. pulchella, *Forb.*	*	*	*	*
,, testudinalis, *Mull.* (sp.); Patella Clealandi, *Sow.*	*	*		
,, fulva, *Mull.* (sp.) Zool. Dan.; Patella Forbesii, *Smith*	...	...	...	*

The above *Scutibranchia* include all but three British species, and which are very rare, viz. *Scissurella crispata*, found at Zetland by Dr. Fleming; *Emarginula rosea* at Poole in Dorsetshire by Professor Bell; and *Puncturella noachina* at Oban, in Argyleshire, by the Rev. R. T. Lowe.

* *T. mammillatus* and *T. tuberosissimus*, the Brit. species.—*Cyclostrema Zetlandica* comes under the genus *Rissoa.*

† *T. subulata*, the Brit. species.

‡ In Mr. Templeton's journal, the following note appears—"Oct. 24, 1811. Received a *Haliotis tuberculatus* dredged up on the county Down shore, near Groomsport." Capt. Brown in his 'Irish Testacea' mentions on the authority of Templeton, that specimens had been obtained at another locality in the same county. Mr. O'Kelly states—in Walsh and Whitelaw's Dublin—that "one specimen was found at Bullock [Dublin coast] and is in the possession of James Tardy, Esq."

Gasteropoda.

Order *Cirrhobranchiata*.

	Distribution. North.	East.	West.	South.
Dentalium dentalis, *Lin.*; D. eburneum	...	*	*	
„ entalis, *Lin.*; D. labiatum, *Brown*	*	*	...	*
„ striatulum, *Turt.* C. D.	...	...	*	*
„ semistriatum, *Turt.* C. D. (on Turton's authority) *	...	*		

The *Dentalium glabrum*, Mont., and *Dent. trachea*, Mont., which come under the genus *Cæcum* of Fleming and *Brochus* of Brown, have been found at Miltown Malbay, on the coast of Clare, by Mr. W. H. Harvey, and at Bundoran, co. Donegal. Capt. Brown figures (pl. 1. Illustrations) three species of *Brochus*, which he calls new, from the coast of Ireland, viz. *B. reticulatus* and *B. annulatus*, from the county of Down; *B. arcuatus* from Bantry bay—at this last locality *B. striatus*, Brown, occurred to myself. Naturalists seem not yet to have agreed about the position of this genus; some make it Annelidan. Mr. Clark of Bath (as I learn from Mr. Alder) proved it to belong to the *Gasteropodous Mollusca*. Philippi brings it—his genus *Odontidium*—under *Pteropoda*.

Gasteropoda.

Order Cyclobranchiata.

	North.	East.	West.	South.
Patella vulgata, *Lin.* (var. P. depressa, *Penn.*, Dublin coast)	*	*	*	*
„ ? intorta, *Penn.* (on Turton's authority.)	...	*?		
„ pellucida, *Lin.*	*	*	*	*
„ lævis, *List.*; P. cœrulea, *Mont.*	*	*	*	*
„ ? exigua, *Forbes*; P. ancyloides, *Forbes*	*			
Chiton fascicularis, *Lin.*	*	*	*	*
„ marginatus, *Penn.* Flem. Br. Anim.	*	*	*	*
„ ruber, *Lin.* Flem. B. A.	*	*	...	*
„ cinereus, *Lin.* Flem. B. A.	*	*	*	
„ fuscatus, *Brown*	*			
„ lævis, *Mont.* Flem. B. A.	*	*	*	*
„ albus, *Lin.* Flem. B. A.	*			
„ lævigatus, Flem. B. A.	*	*	*	

The above species of *Cyclobranchia* perhaps include all those published that can be given with certainty as British.

Class Acephala.

Order Brachiopoda.

	North.	East.	West.	South.
Terebratula psittacea, *Turt.*	...	*		
„ aurita, *Flem.*	*			
Crania personata, *Sow.*; Criopus anomalus, *Flem.*	...	...	...	*

Turton mentions a single specimen of "*Anomia terebratula*" dredged alive in Dublin bay and placed in the museum of the Dublin Society. In August last, when visiting this collection in company with Mr. Alder, a *Terebratula psittacea* (sp.) labelled "Dublin bay," was observed, but whether it was the shell alluded to by Turton we could not ascertain. On looking over the Ordnance Museum we saw a specimen of *T. aurita*, which was dredged at the entrance of Belfast bay. *Crania personata* has been brought up from very deep water off Youghal by Mr. R. Ball, and has been obtained by Mr. John Humphreys on *Pinna ingens*, &c., dredged in Cork harbour and off Kinsale. The British

* Turton's *Dentalium clausum* is advisedly omitted as a species.

list contains but one species in addition to those named as Irish—the *Ter. cranium*, which is occasionally taken at Zetland.

	Distribution.			
	North.	East.	West.	South.
Class ACEPHALA.				
Order LAMELLIBRANCHIATA.				
Div. MONOMYARIA.				
Fam. *Ostreadæ.*				
Anomia electrica, *Lin.* / „ ephippium, *Lin.*; A. cepa, *Lin.* } one species	*	*	*	*
„ squamula, *Lin.*	*	*	*	*
„ undulata, *Gm., Mont.*	*	*	...	*
„ punctata, *Turt.*	...	...	...	*
„ cylindrica, *Turt.*; A. cymbiformis	*	*	...	*
„ aculeata, *Mont.*	*	*	...	*
Ostrea edulis, *Lin.*; O. parasitica, *Turt.* (young)	*	*	*	*
Fam. *Pectenidæ.*				
Pecten maximus, *Lin.* (sp.)*	*	*	*	*
„ opercularis, *Lin.*	*	*	*	*
var. P. lineatus	*	*	...	*
„ sinuosus, *Turt.*	*	*	*	*
„ glaber, *Penn., Mont.*	...	...	...	*
syn.? P. nebulosus, *Brown*	*?			
„ lævis, *Penn., Mont.*; P. tumidus, *Turt.*; P. similis, *Laskey*, one species? (*E. Forbes*)	...	*	...	*
„ obsoletus, *Penn., Don.*	*	*	...	*
„ varius, *Lin.* (sp.)	*	*	*	*
Lima fragilis, *Mont.*	*	*	...	*
„ tenera, *Turt.* Zool. Journ. vol. ii.	*			
„ subauriculata, *Mont.* (sp.)	*			
Div. DIMYARIA.				
Fam. *Aviculadæ.*				
Avicula atlantica, *Lam.*†	...	*	...	*
Fam. *Arcadæ.*				
Arca Noæ, *Lin.*	...	...	...	*
„ fusca, *Mont.* (not *Lam.*); A. tetragona of authors.	*	*	*	*
„ lactea, *Lin.?*, *Mont.* (the species marked with doubt by Turton)	...	...	*	
„ barbata, *Brown*, Wern. Mem. vol. ii. p. 512. pl. 24. f. 3. (I.)	*			
Pectunculus pilosus, *Lin.* (sp.); P. decussatus, *Turt.*; P. nummarius, *Turt.*	*	*	...	*
Nucula margaritacea, *Lam.*; Arca nucleus, *Lin.*	*	*	*	*
„ minuta, *Mont.* (sp.)	*	*	*	
„ tenuis, *Mont.* (sp.)	...	*		
„ nitida, *Sow.* Conch. Illus. f. 20	...	*		
Fam. *Mytilidæ.*				
Mytilus edulis, *Lin.*; M. incurvatus, M. subsaxatilis, &c.	*	*	*	*
Crenella decussata, *Laskey* (sp.); Myt. decussata, *Mont.*; Cren. elliptica, *Brown*, Illus.	*			
Modiola vulgaris; Myt. modiola, *Penn.*; Mod. papuana, *Lam.*	*	*	...	*
„ tulipa, *Lam.*	*	*		

* *P. jacobæus* is noticed by Turton, &c. as an Irish shell, but I believe erroneously.

† The specimens of *Avicula hirundo* obtained by Miss Hutchins at Bantry bay and Mr. Warren at Portmarnock, are most probably this species. *Vide* Lam. tom. vii. p. 99. 2nd edit.

Fam. *Mytilidæ*.

Species	Distribution: North.	East.	West.	South.
Modiola Gibsii, *Leach*	...	...	*	*
,, ———— ? (I.)	...	...	...	*
,, discrepans, *Mont.* (sp.), not *Lam.*	*	*	*	*
,, marmoratus, *Forb.* Malacol. Monensis, p. 44; Myt. discors, *Mont.* (see Lam. vii. p. 23. 2nd ed.)	*	*	*	*
Pinna fragilis, *Turt.* Brit. Biv. (one species)	*	*	...	*
,, pectinata, ,, ,, (one species)	...	...	...	*
,, muricata, ,, ,, (one species)	...	...	...	*
,, papyracea, ,, ,, (one species)	...	...	...	*

Fam. *Unionidæ*.

Species	North.	East.	West.	South.
Anodon cygneus; Mytilus cyg., *Mont.*; A. cyg. and A. anatina, *Drap.*; A. intermedia and A. cellensis, *Pfeiff.* (one species)	*	*	*	
Alasmodon margaritiferum; Mya marg., *Mont.*; Unio marg., *Drap.*	*	...	*	*

Fam. *Camacadæ*.

Species	North.	East.	West.	South.
Isocardia cor; Chama cor, *Lin.*; I. Hibernica, *Bulwer*	*	*	...	*

Fam. *Conchaceæ*.

Species	North.	East.	West.	South.
Cardium echinatum, *Lin.*	*	*	...	*
,, elongatum, *Mont.*	...	*	...	*
,, nodosum, *Mont.*	*	*	*	
,, exiguum, *Mont.*	*	*	*	*
,, edule, *Lin.*	*	*	*	*
,, var. fasciatum, *Mont.*	...	*	...	*
,, medium, *Lin.*	*	*		
,, lævigatum, *Lin.*; C. serratum	*	*	*	*
,, ———? (I.)	*			
Donax trunculus, *Lin.*; D. rubra, *Turt.* Br. Biv. (young)	*	*	*	*
,, denticulata, *Lin.* (noticed by Brown and Turton only)	...	*	*	
,, complanata, *Mont.*	...	...	...	*
Tellina punicea, *Turt.*	* ?			
,, fabula, *Don.*	*	*	*	*
,, similis, *Sow.*	...	*		
,, donacina, *Lin.*	*	*	...	*
,, bimaculata, *Lin.*, *Don.**	...	...	*	*
,, squalida, *Mont.*; T. depressa, *Don.*	*	*	...	*
,, tenuis, *Don.*	*	*	*	*
,, crassa, *Penn.*; T. maculata, *Turt.* Br. Biv.	...	*	*	*
,, solidula, *Mont.*	*	*	...	*
,, carnaria, *Lin.*, *Don.* (on Turton's authority)	...	...	*	
Lucina radula; Tell. rad., *Mont.*	*	*	*	*
,, rotundata; Tell. rot., *Mont.*	...	...	...	*
,, spinifera; Venus spin., *Mont.*; Myrtea spin., *Turt.*	*	*	*	*
,, flexuosa; Tell. flex., *Mont.*	*	*	*	*
Amphidesma† prismaticum, *Laskey* (sp.)	*	*	...	*
,, Boysii, *Turt.* Br. Biv.	*	*	*	*
,, tenue; Ligula tenuis, *Mont.*	*			
,, ——? (I.)	*	...	*	
Cyprina Islandica; Venus Isl., *Lin.*	*	*	*	*

* As this species is considered by some naturalists to have been erroneously introduced into our catalogues, it may be stated that Mr. R. Ball has specimens of it collected on the coasts of Clare and Cork, and that Mr. Warren of Dublin obtained one in a living state at Ardmore, county Waterford.

† Montagu's generic name *Ligula* should perhaps be adopted instead of *Amphidesma*.

Fam. *Conchaceæ.*

	Distribution.			
	North.	East.	West.	South.
Cyprina minima; Venus min., *Mont.*	...	...	*	*
„ triangularis; Venus tri., *Mont.* (on Turton's authority)	...	*		
Mactra solida, *Penn., Mont.*; M. crassa	*	*	*	*
„ elliptica, *Brown,* Illust.	*	*		
„ truncata, *Mont.*	*	*	*	*
„ subtruncata, *Mont.*	*	*	*	*
„ stultorum, *Lin.*	*	*	*	*
var. M. cinerea, *Mont.*	*	*		
Goodallia triangularis; Mactra tri., *Mont.*	*			
„ minutissima; Mactra min., *Mont.* (on Turton's authority)	...	*		
Lepton squamosum; Solen squam., *Mont.*	...	...	...	*
Kellia suborbicularis; Mya sub., *Mont.*	*	...	*	*
„ rubra; Cardium rubrum, *Mont.*	*	*	*	*
Montacuta substriata; Ligula sub., *Mont.*	*			
„ bidentata; Mya bid., *Mont.*	*	*	*	*
„ ferruginosa; Mya fer., *Mont.*	...	*		
„ ovata; Tellimya ovata, *Brown,* Illust.	...	*	*	*
„ purpurea; Mya purp., *Mont.*	*	*	*	
Ervilia nitens; Mya nitens, *Laskey, Mont.* (on Turton's authority)	...	*		
Cyclas cornea; Tellina cornea, *Lin.*	*	*	*	*
„ lacustris; Tellina lac., *Mull.*; C. calyculata, *Drap.*				
Pisidium obtusale, *Pfeif.*? *Jenyns*	*	...	...	*
„ nitidum, *Jen.*	*	*	*	*
„ pusillum, *Jen.*	*	*	*	*
„ pulchellum, *Jen.*	*	*	*	*
„ Henslowianum, *Jen.*; Cyc. appendiculata, *Turt.* Man.	...	...	...	*
„ amnicum; Cardium amni, *Mont.*; Cyclas palustris, *Drap.*	*	*	*	
„ cinereum, *Alder*	*	*	*	*
Astarte Damnoniæ; Venus Damn., *Mont.*	*	*	...	*
„ Scotica; Venus Scot., *Mont.*	*	*	...	*
„ „ ? (I.)	*			
Artemis exoleta; Venus ex., *Lin.*	*	*	*	*
„ lincta; Venus lincta, *Pult.*	*	*	*	*
„ ? undata; Venus undata, *Penn., Mont.*	*	*		*
Cytherea tigerina; Venus tig., *Lin.* (on Brown's authority)	...	*		
„ ovata; Venus ovata, *Penn., Mont.*	*	*	*	*
Venus verrucosa, *Lin.*; V. cancellata, *Lin., Turt.* (young)	*	*	*	*
„ cassina, *Lin.*; syn. V. reflexa, *Lask., Mont.*	*	*	*	*
„ fasciata, *Don**	*	*	*	*
„ Pennantii, *Forb.,* Malac. Monensis, 52; V. rugosa, *Penn.*; V. laminosa, *Laskey*	*	*	*	*
„ gallina, *Lin.*	*	*	*	*
„ sinuosa, *Penn.* (on the authority of Brown and Turton)	...	*	...	*
„ ———? ——————— (I.)	...	...	...	*
„ ———? ——————— (I.)	...	*		
Pullastra aurea; Venus aurea, *Mont.*; syn. V. nitens, *Turt.*; V. ænea, *Turt., E. Forbes*	*	*	*	*
„ perforans; Venus perf., *Mont.*	*	*	*	*
„ vulgaris, *Sow.*; Venus pullastra, *Wood, Mont.*	*	*	*	*
„ decussata; V. dec., *Lin.*	*	*	*	*
„ virginea; V. virg., *Lin.*	*	*	*	*
var. V. Sarniensis	*	*		
Venerupis irus; Donax irus, *Lin.*	...	*	*	*
Petricola ochroleuca, *Lam.*; Psam. fragilis, *Turt.* Br. Biv. (I.)	...	...	...	*

* *Venus dysera* of Bryce's Tables, &c. is a variety of *V. fasciata.*

	Distribution.			
	North.	East.	West.	South.
Fam. *Pyloridæ.*				
Corbula striata; Mya inæquivalvis, *Mont.*	·	*	...	*
Sphenia Binghami, *Turt.* Br. Biv.	...	*?		
Pandora obtusa, *Leach, Lam.**	*			
Thracia convexa; Anatina conv., *Turt.* Br. Biv.	*	*	...	*
„ pubescens; „ pub., „ „	*	*	*	*
„ declivis; „ dec., „ „	*	*	...	*
„ distorta; „ dist., „ „	...	*	...	*
Anatina prætenue, „ „	*	*	...	*
Mya truncata, *Lin.*; Sphenia Swainsoni, *Turt.*, young, *E. Forbes*	*	*	*	*
„ arenaria, *Lin.*	*	*	*	*
Lyonsia Norvegica; "Mya Norv., *Turt., Lin.*"	*	*	*	*
Lutraria vulgaris; Mactra lutraria, *Lin.*	...	*	*	*
„ hians; Mactra hians, *Pult., Don.*	*	...	...	*
„ compressa; Listera comp., *Turt.* Br. Biv.	*	*	*	*
Psammobia tellinella, *Lam.*; P. florida, *Turt.* Br. Biv.	*	*	...	*
P. costulata, *Turt.*, syn. with last	...	...	...	*
„ Ferroensis; Tellina Fer., *Mont.*	*	*	*	*
„ vespertina, *Turt.*; P. florida, *Lam.* (but not of British authors) is the form found in Scotland (*E. Forbes*)	*	...	*	*
Solen vagina, *Lin.*	*	*	...	*
„ siliqua, *Lin.*	*	*	*	*
syn.? S. novacula, *Mont.*	*	*		
„ ensis, *Lin.*	*	*	*	*
„ pellucidus, *Penn., Don.*	*	*	...	*
„ legumen, *Lin.*	...	*	...	*
„ antiquatus, *Pult., Don.*	*	*	...	*
„ fragilis, *Pult., Mont.*				
„ strigillatus; Psammobia strig., *Turt.*	...	*	...	*
Saxicava rugosa; Mytilus rug., *Lin.*; syn. Hiatella arctica, *Flem.*	*	*	*	*
Fam. *Tubicolæ.*				
Gastrochæna pholadia, *Mont.* (sp.); Mya phol., *Mont.*; Gast. hians, *Flem.*; Mya dubia, *Penn.*	...	...	*	*
Pholas crispata, *Lin.*	*	*	...	*
„ lamellata, *Turt.*	*	*?		
„ striatus, *Lin., Don.*; "conoides, Parsons," *Flem.* Br. Anim.	...	...	*	
„ dactylus, *Lin.*	*	*	...	*
„ parvus, *Mont.*	*			
„ candidus, *Lin.*	*	*	...	*
Teredo bipinnata, *Turt.*	...	...	*	*
„ navalis, *Lin.*	*	*	*	*
Xylophaga dorsalis, *Turt.*	...	*		

About 220 species of *Lamellibranchia* are included in the British Fauna, of which 155 are Irish: to these, eight only—indicated in the usual manner in the preceding table—can be added, which have not a place in the catalogue of Great Britain, making the total number of Irish species 163. The *marine* species of that island unknown to us are the rarest there, not one of the many being common, and nearly all being local and confined to one district. It is not so with the *freshwater* species, *Unio pictorum*, *U. tumidus*, and *Cyclas rivicola*, which are more widely diffused, but at the same time become rare

* *Pandora inæquivalvis* (*P. rostrata*, Lam.). In Turton's catalogue of Irish Shells it is stated that specimens said to be from Bantry were shown him, but in his subsequent works (Conch. Dict. and Brit. Biv.) no Irish station is given for the species.

towards the north of England, and are not found at all in Scotland. The generic forms wanting in Ireland are *Lithodomus, Capsa, Panopœa, Galeoma, Unio, Crenatula, Neæra**, all of which, with the exception of *Unio*, are very rare:—they have each but one representative British species.

Mollusca Tunicata.	Distribution. North.	East.	West.	South.
Ascidia mentula, *Mull.* Zool. Dan. vol. i. p. 6. t. 8. f. 1–4. (Phallusia, *Sav.*)	*	...	*	
„ rustica, „ „ „ p. 14. t. 15. f. 1–5. (Phallusia)...	*	*	*	
„ venosa, „ „ „ p. 25. t. 25. (I.)	*			
„ prunum, „ „ „ p. 42. t. 34. f. 1–3	*	...	* ?	
„ conchilega, „ „ „ p. 42. t. 34. f. 4–6	*			
„ parallelogramma, „ vol. ii. p. 11. t. 49. (I.)	*			
„ canina, „ „ „ p. 19. t. 55. f. 1–6. (Phallusia) (I.)	...	...	*	
„ aspersa, „ „ „ p. 32. t. 65. f. 2. (I.)	*			
„ scabra, „ „ „ p. 33. t. 65. f. 3. (I.)	*	...	*	
„ orbicularis, „ „ „ p. 53. t. 79. f. 1 & 2. (I.)	*			
„ echinata, „ „ vol. iv. p. 10. t. 130. f. 1	*			
„ mammillaris, Delle Chiaje, vol. iii. p. 187. 197. t. 45. f. 14. (I.) ...	*			
„ gemina, *Templeton* (R.) Mag. Nat. Hist. vol. vii. p. 129. f. 24. (I.)	*			
„ anceps, „ „ „ „ p. 130. f. 25. A. prunum? (I.?)............	*			
„ communis, *Forbes* MSS.	...	...	*	
Phallusia intestinalis, *Sav.* Mem. p. 169. t. 11. f. 1	*	...	*	
Cynthia microcosmus, „ „ p. 144. t. 2. f. 1. (I.)................	*	*	*	
„ claudicans, „ „ p. 150. t. 2. f. 1. (I.)................	*			
Clavellina lepadiformis, *Sav.*; Ascidia lepad., *Mull. Z.* D. vol. ii. p. 54. t. 79. f. 5.	*	*	*	
Distoma rubrum, *Sav.* Mem. p. 177. t. 3. f. 1. and t. 13. (I.)	*			
„ variolosum, *Gaert.* Sav. Mem. p. 38. & 178?	*			
Aplidium ——? (more than one species)	*	...	*	
Sydneum turbinatum, *Sav.* Mem. p. 239?	*			
Amaroucium proliferum, *Edw.* Ascid. Compos., p. 67. pl. 1. f. 3. (I.) ...	*			
Leptoclinum gelatinosum, „ „ „ p. 83. pl. 8. f. 1. (I.) ...	*			
„ maculosum, „ „ „ p. 81. pl. 8. f. 2. (I.) ...	*			
„ asperum, „ „ „ p. 82. pl. 8. f. 3. (I.) ...	*			
„ durum, „ „ „ p. 82. pl. 8. f. 4. (I.) ...	*			
Botryllus Schlosseri, *Lin.* (sp.) Phil. Trans. vol. xlix. p. 449. pl. 14	*	*		
„ Leachii, *Sav.* Mem. p. 199. pl. 4. f. 6. & pl. 20. f. 4	*			
„ polycyclus, *Sav.* Mem. p. 47. pl. 4. f. 5 (I.)	*	...	*	
„ gemmeus, *Sav.*, Edw. Ascid. Comp. p. 89. pl. 6. f. 5. (I.)	*			
„ bivittatus, *Edw.* „ „ „ p. 92. pl. 6. f. 7. (I.)	*			

In Loudon's Magazine of Natural History, vol. vii. p. 129, Mr. R. Templeton described and figured two species of the *Moll. Tunicata*, and eighteen more were recorded by myself in the Annals of Nat. Hist., vol. v. p. 93:—in the 13th volume of the latter work the additional species introduced here will be more particularly noticed. My knowledge of the *Tunicata* not being advanced beyond the identification of the species with those of the authors cited, the names are given in the consecutive order in which they appear in their works, without any attempt being made to bring the species ("simple" Ascidiæ) under their modern genera. Such of Muller's species as Savigny brought under certain of his genera have these added within brackets in the accompanying table.

* The introduced *Dreissena* is not included.

So little attention has been bestowed on the *Mollusca Tunicata* of Great Britain and Ireland, that it is perhaps unnecessary to draw the usual comparison. More Irish than British species can however be announced. Of the thirteen British simple Ascidians recorded, seven are Irish, in addition to which are eleven unrecorded as indigenous to the coasts of the larger island. Of the ten "compound" species published as British five are Irish, to which latter nine, unnoticed as indigenous to the seas of Great Britain, are to be added: all the species of the preceding catalogue marked (I.) are probably to be found on the British coast. So little of the history or geographical distribution of the *Moll. Tunicata* is known that the mere record of the species obtained in any locality possesses interest. The greater number of those here noticed are identical with the species found by Muller on the coast of Denmark; several, both of the "simple" and "compound," are the same as those of France described by Savigny and Milne Edwards, and a few of each division to those procured by Delle Chiaje on the coast of Naples.

Nearly all the species enumerated here were taken by dredging, as were a number of others (simple and compound) which are still undetermined. Professor Edward Forbes and Mr. John Goodsir, in the course of their dredging, have collected many species from various parts of the British coast, a very few of which are yet published.

To take a general view of the Mollusca of Ireland, as exhibited in the preceding catalogue, it would seem, regarding the subject positively, that a respectable knowledge of all the classes and orders has been acquired, and regarding it comparatively, that on the whole the species have been perhaps as well ascertained as those of Great Britain. The relative difference in the number of species (except perhaps in Nudibranchia) will probably hold good after the closest investigation of the subject in both islands: in the Bivalves only among the Testacea is the difference very striking. Considering the geographical position of the two islands, the smaller one being the farther removed from the great continental coast, the shores of Ireland being only about one-third the extent of those of the larger island, and what is of more consequence, limited to one-third of the degrees of latitude over which Great Britain with its neighbouring islands (whose fauna it includes) extend, the relative number of species known as Irish is as great as would *à priori* be anticipated.

CIRRHIPEDA.

The species of Irish Cirrhipeda known to Brown and Turton were included in their catalogues of "Testacea." Capt. Portlock, in bringing before the Royal Irish Academy (Jan. 23, 1837) a notice of *Anatifa vitrea*, read a list of the native Pedunculated Cirrhipeda, communicated to him by Mr. R. Ball*; and additional species have been contributed by myself to the Annals of Nat. Hist. vol. xiii.

CIRRHIPEDA. *Cirr. Pedunculata.*	Distribution. North.	East.	West.	South.
Anatifa lævis, *Lam.*; Lepas anatifera, *Lin.*	*	*	*	*
,, dentata, *Lam.*; var. A. lævis, *W. T.*	*			
,, striata, *Lam.*; Lep. anserifera, *Lin.*	*	*	*	*

* Proceedings of the Royal Irish Academy, vol. i. p. 30.

CIRRHIPEDA.

Cirr. Pedunculata.

	Distribution.			
	North.	East.	West.	South.
Anatifa vitrea, *Lam.*; L. fascicularis, *Mont.*	*	...	*	*
„ sulcata, *Lam.*; L. sul., *Mont.*	...	...	*	*
Scalpellum vulgare, *Leach*; L. scalp., *Lin.*	*	*		
Pollicipes cornucopiæ, *Leach*; L. pollicipes, *Gmel.*	...	*		
Cineras vittata, *Leach*; L. membranacea, *Mont.*	*	*		
Otion Cuvieri, *Leach*; L. aurita, *Lin.*	*	*	...	*?
Cirrhipeda Sessilia.				
Balanus costatus, *Mont.*; B. angulosus, *Lam.*	*	*	...	*
„ communis*, *Mont.*; Lepas balanus, *Lin.*? Bal. sulcatus, *Brug. Lam.*	*	*	...	*
„ tintinnabulum, *Lin.* (sp.)	*?	*	...	*
„ ovularis, *Lam.*; Bal. balanoides, *Mont.*	*	*	...	*
„ rugosus*, *Mont.*	*	*		
„ Scoticus, *Wood* (sp.), Brown's Illust. pl. 7. f. 22†	*	*		
„ candidus, *Leach*, „ „ pl. 6. f. 8–10	...	*		
„ punctatus*, *Mont.*	...	*	...	*
„ fistulosus, *Brug. Lam.*; B. clavatus; Lepas elongata, *Chem.* ...	*	*	...	*
Creusia verruca, *Leach, Lam.*; Lepas striata, *Penn.*	*	*	...	*

The preceding catalogue exhibits nearly all the species of Cirrhipeda which have a place in the British Fauna; but as these have not been satisfactorily determined, the usual comparison is omitted. Several of the species can hardly be called natives of our seas, although found living on the bottoms of ships in our harbours, and attached to timber cast ashore; but by including them here I only follow British and French authors. Some species, if not native, have become naturalized to a limited extent, and take up their abode on the "wooden walls" of our docks, flood-gates, &c. The *Coronula diadema*, which has been obtained on the skin of whales killed on the British coast, and the *Acasta Montagui*, Leach, found imbedded in sponge, cannot be announced with certainty in the Irish catalogue.

CRUSTACEA.

Some species of Irish Crustacea have been recorded in the celebrated 'Zoological Researches' of Mr. John Vaughan Thompson, and his other writings‡; by Templeton's catalogue of all the species known to him, published in the ninth volume of Loudon's Magazine of Natural History; by contributions of Mr. Robert Templeton, to the second volume of the Entomological Transactions; and by communications of my own to the Annals of Natural History, vols. v. (pp. 221 & 255), vii. (p. 482), x. xi. & xiii.

The collections of Dr. Drummond, Mr. Hyndman and the Ordnance Survey, from the north-east coast; of Mr. R. Ball from Youghal and Dublin; of Dr. Bellingham (in *Syphonostomata*) from the last-named locality; and of

* The names of *Balanus communis*, *B. rugosus*, and *B. punctatus* have been applied to other species on the continent. See Lamarck, vol. v. 2nd edit.

† See correction of *B. Scoticus* and *B. candidus* in description of plate 32.

‡ Papers in the Philosophical Transactions, 1835, and Entomological Magazine (vol. iii.), and Museum Catalogue of the Royal College of Surgeons, Dublin:—his whole collection of *Crustacea* now belongs to this College, and is exhibited in its museum; the Irish species are indicated by the initial "I."

Dr. Geo. J. Allman (*Syphonostomata*) from the coast of Cork, have, in addition to my own, aided in this department.

I have throughout followed the arrangement adopted in the excellent 'Histoire des Crustaces' of Milne Edwards.

CRUSTACEA.

1st Legion PODOPHTHALMATA.

Order DECAPODA.

1st Section *Brachyura*.

	Distribution. North.	East.	West.	South.
Macropodia phalangium, *Leach**	*	*	*	*
Achæus Cranchii, *Leach*	...	...	...	*
Inachus Dorsettensis, *Leach*	*	*	*	*
,, leptochirus, *Leach*	*	...	*	
,, dorhynchus, *Leach*	*			
Pisa tetraodon, *Leach*	...	...	*	
Hyas aranea, *Leach*	*	*	*	*
,, coarctata, *Leach*	*	*	...	*
Maia squinado, *Latr.*, *Leach*	...	...	*	*
Eurynome aspera, *Leach*	*	*	*	*
Xantho floridus, *Leach*	*	*	*	*
,, rivulosus, *Risso*, *Edw.*	*			
Cancer pagurus, *Leach*	*	*	*	*
Pilumnus hirtellus, *Leach*	*	*	*	*
Pirimela denticulata, *Leach*	*	...	*	
Carcinus mænas, *Leach*	*	*	*	*
Portumnus variegatus, *Leach*	*	*		
Portunus puber, *Leach*; Cancer velutinus	*	*	*	*
,, depurator, *Leach*	*	*	*	*
,, lividus, *Leach*	*	*		
,, corrugatus, *Penn.* (sp.)	*			
,, pusillus, *Leach*	*	*	*	*
,, arcuatus, *Leach*	*	*	*	*
Pinnotheres pisum, *Leach*; P. varians, *Leach*; P. Latreilli, *Leach*	*	*	*	*
,, pinnæ; P. veterum, *Leach*	...	...	...	*
Gonoplax angulata, *Edw.*; G. bispinosa, *Leach*	*	*	...	*
Ebalia Bryerii, *Leach*	*			
,, Cranchii, *Leach*	*	*	*	
,, Pennantii, *Leach*	*	*	...	*
Atelecyclus heterodon, *Leach*	*	*	*	*
Corystes cassivelaunus, *Leach*	*	*	...	*

Order DECAPODA.

2nd Section *Anomoura*.

	North.	East.	West.	South.
Lithodes maia, *Leach*	...	...	...	*
Pagurus Bernhardus, *Edw.*; P. streblonyx, *Leach*	*	*	*	*
,, Prideauxii, *Leach*	*			
,, erinaceus, *Thomp.* (*J. V.*) (I.)	...	...	...	*
,, Hyndmani, *Thomp.* (*W.*) MSS. (I.)	*			
,, Cuanensis, *Thomp.* (*W.*) MSS. (I.)	*			
,, Ulidiæ, *Thomp.* (*W.*) MSS. (I.)	*			
,, lævis, *Thomp.* (*W.*) MSS. (I.)	*			
Porcellana platycheles, *Edw.*	*	*	*	
,, longicornis, *Edw.*	*	*	*	*

* For the sake of brevity the names applied by Leach are generally given without reference to those first applied to the species.

Order Decapoda.

3rd Section *Macroura*.

	North.	East.	West.	South.
Galathea strigosa, *Edw.*; G. spinigera, *Leach*	*	*	...	*
„ rugosa, *Leach*	*	...	...	*
„ squamifera, *Leach*	*	*	*	*
„ nexa, *Embleton*, Proceedings Berwickshire Club, vol. i. p. 71. pl. 1	*			
Palinurus vulgaris, *Leach*	*	*	*	*
Callianassa subterranea, *Leach*	*			
Astacus fluviatilis, *Edw.* (Introduced to some places.)	*	*	*	*
Homarus vulgaris, *Edw.*	*	*	*	*
Nephrops Norvegicus, *Leach*	*	*		
Crangon vulgaris, *Leach*	*	*	*	*
Pontophilus spinosus, *Leach*	...	...	...	*
Processa canaliculata, *Leach*	...	...	...	*
Athanas nitescens, *Leach*	...	...	*	
Hippolyte varians, *Leach*	*	*	*	*
„ Cranchii, *Leach*	...	...	...	*
Pandalus annulicornis, *Leach*	*	*	*	*
Palæmon serratus, *Leach*	*	*	*	*
„ squilla, *Leach*	*			
„ varians, *Leach*	*			
„ Leachii, *Thomps.* (*J. V.*) (I.)	...	...	..	*
Pasiphæa sivado, *Risso* (I.)	...	*		
?Alauna rostrata, *Goodsir*, Edin. Phil. Journ. vol. xxxiv. p. 130. pl. 4. ?	*			
?Cuma trispinosa, „ „ „ 129. „ 3. f. 1	*			

Order Stomapoda*.

	North.	East.	West.	South.
Mysis spinulosus, *Leach*; M. Leachii, *Thomp.* Zool. Research.	...	...	...	*
„ chamæleon, *Thomp.* (*J. V.*)	...	...	...	*
„ vulgaris, *Thomp.* (*J. V.*)	...	...	...	*
Scorpionura vulgaris, *Thomp.* (*J. V.*) Museum Catalogue Royal College of Surgeons in Ireland, p. 229	...	...	...	*
„ longicornis, „ „ „ „ „	...	...	...	*
„ maxima, „ „ „ „ „	...	...	...	*

2nd Legion Edriophthalmata.

Order Amphipoda.

	North.	East.	West.	South.
Talitrus locusta, *Latr.*; T. saltator, *Edw.*	*			
Orchestia littorea, *Leach*	*	...	...	*
Dexamine spinosa, *Leach*	*			
Gammarus locusta, *Fabr.*	*	...	...	*
„ fluviatilis, *Edw.*†	*	*	*	*
Corophium longicorne, *Latr.*	*	...	...	*
Hyperia ——— ?	*	*	...	*

Order Lœmodipoda.

	North.	East.	West.	South.
Caprella phasma, *Latr.*; Cancer phasma, *Mont.*	...	...	...	*

* From this to the end of the Crustacea little attention has been given to noting the distribution of the species on our coasts.

† All my specimens from many localities are of this species as distinguished from *G. pulex*, Edw. Crust. vol. iii. p. 45 & 48.

Order Lœmodipoda.

	Distribution. North.	East.	West.	South.
Caprella linearis, *Latr.*	*			
Proto pedatum, *Leach*; Leptomera pedata	*			

Order Isopoda.

	Distribution. North.	East.	West.	South.
Arcturus longicornis, *Westwood*	*	*		
Idotea pelagica, *Leach*; I. tricuspidata, fig. only*; Desmarest, Cons., Crust. pl. 46. f. 11	...	*	...	*
„ tricuspidata, *Edw.*; I. entomon, *Leach*	*	...	*	*
„ emarginata, *Edw.*; I. œstrum, *Leach*	*			
„ linearis, *Edw.*; Stenosoma lin., *Leach*	*	...	...	*
Limnoria terebrans, *Leach*	*	*	*	*
Asellus aquaticus, *Oliv.*; A. vulgaris, *Latr.*, *Edw.*	*			
Lygia oceanica, *Fabr.*	*	*	...	*
Oniscus asellus, *Lin.*	*	...	...	*
Philoscia muscorum, *Latr.*	...	...	...	*
Porcellio scaber, *Latr.*	*			
„ lævis, *Latr.*	*			
Armadillidium† vulgaris, *Edw.*; Armadillo vulg., *Latr.*	*	*	...	*
Anceus maxillaris, *Lam.*; A. rapax, *Edw.*, vol. iii. p. 196. pl. 33. f. 12‡	*	...	...	*
Sphæroma serratum, *Leach*	*			
„ Hookeri, *Leach*	...	...	...	*
„ rugicauda, *Leach*	*			
Nesæa bidentata, *Desm.*	*			
Dynamena rubra, *Leach*	*			
Cirolana Cranchii, *Leach*	*	*		
Ægа bicarinata, *Leach*	*			
„ tridens, *Leach*	*			
Bopyrus squillarum, *Latr.*	...	...	*	
„ ——— ? §	...	...	*	
„ galatea, *Thomp.* (*J. V.*) MSS.‖	...	...	...	*

3rd Legion Branchiopoda.

Order Phyllopoda.

	Distribution. North.	East.	West.	South.
Apus cancriformis, *Latr.*	*			
Branchipus stagnalis, *Latr.*	*			

Order Cladocera.

	Distribution. North.	East.	West.	South.
Daphnia pulex, *Mull.*	*			
„ longispina, *Mull.*	*			
Polyphemus oculus, *Mull.*	*			

* See Edw. Crust. vol. iii. p. 129, note.

† Genus established by Brandt. See Edw. Crust. vol. iii. p. 180.

‡ I have no doubt of the identity of Montagu's *Cancer maxillaris*, Linn. Trans. vol. vii. p. 65. pl. 6. f. 2, and Edw. *A. rapax*, above cited. See remarks on this subject in Edw. Crust. vol. iii. p. 197.

§ I find a *Bopyrus* commonly in *Hippolyte varians*, Leach, but have not yet critically examined it. Two species of *Bopyrus*—*B. hippolyte* and *B. abdominalis*—are described by Kroyer as found in the genus *Hippolyte*. See Edw. Crust. vol. iii. p. 283, and Ann. Sci. Nat. vol. xvii. p. 142. pl. 6. 1842.

‖ In *Galathea squamifera* in Mr. R. Ball's collection there is a species of *Bopyrus*.

4th Legion Entomostraca.

Order Ostrapoda.

Species	Distribution. North.	East.	West.	South.
Cypris conchacea, *Desm.*	*			
,, candida, *Desm.*, *Baird*	*			
,, ——— ?	*			
Cytherea viridis, *Latr.*	*			
,, lutea, *Latr.*	*			

Order Copepoda.

Species	North.	East.	West.	South.
Cyclops quadricornis, *Latr.*; C. vulgaris, *Edw.* Crust.	*			
,, longicornis, *Mull.*	*			
,, ——— ?	*			
Cyclopsina staphylinus, *Edw.* Crust.; Cyclops minutus, *Mull.*	*			
Anomalocera Pattersonii, *Templ.* (*R.*), Entom. Trans. vol. ii. p. 34. pl. 5.*	*			

Order Siphonostomata.

Species	North.	East.	West.	South.
Argulus foliaceus, *Jurine*	*			
Caligus Mulleri, *Leach*†	*			
" ,, salaris," *J. V. Thompson's* Catal. Mus. Coll. of Surg. Ireland	...	...	...	*
" ,, scombri," ,, ,, ,, ,, ,,	...	...	...	*
productus, *Mull.*‡	*			
Cecrops Latreillii, *Leach*	...	...	...	*
Dichelestion sturionis, "*Hermann*," *Edw.*	...	...	...	*

Order Lerneada.

Species	North.	East.	West.	South.
Lernea uncinata, *Mull.*§	*	*		
Chondracanthus cornutus, *Cuv.*, *Edw.*	...	*		
,, lophii, *Johnst.* Mag. Nat. Hist. vol. ix. p. 81. f. 16	...	*		
Entomoda canicula, *Thomp.* (*J. V.*) Catal. Coll. Surg.	...	...	...	*
,, puella‖, ,, ,, ,, ,,	...	...	...	*
Brachiella salmonea, *Templ.* Mag. Nat. Hist. vol. ix. p. 239‖	*			
Lerneonema monillaris, *Edw.*¶	...	...	...	*
Lernea branchialis, *Lin.*	*	*	...	*

Order Pychnogonida.

Species	North.	East.	West.	South.
Nymphum gracile, *Leach*	*			
,, grossipes, *Lin.* (sp.)**	*			
Orythia coccinea, *Johnst.* Mag. Zool. & Bot. vol. i. p. 378. pl. 13. f. 4–6	*			
Pychnogonum littorale, "*Strom.*" (sp.); *Edw.* P. balænarum	*	*		

Of the thirty-six British species of *Brachyura*, all but six are known as Irish, and of these, one—*Portunus marmoreus*—is recorded as such, but the specimens so named which have come under my observation are *P. pusillus* (see Annals Nat. Hist. vol. x.); another—*Portunus emarginatus*—is believed to be only a variety of *P. arcuatus*, which is found around our coast. The other four species are *Macropodia tenuirostris*, *Pisa Gibbsii*, *Polybius Henslowii*, and *Pinnotheres Montagui*, all of which were known to Leach as in-

* Probably a species in its immature state.

† See Edw. Crust. vol. iii. p. 450. ‡ *Ibid.*, p. 465. § *Ibid.*, p. 495.

‖ Merely indicated here; no author's name appended to the species.

¶ *Foroculum Spratti* is the name applied to a species in J. V. Thompson's Catal. Mus. Coll. Surg.

** A species of *Ammothea* is named *A. æruginosa*, and marked as Irish in J. V. Thompson's collection. Mus. Catal. Royal Coll. Surg. Ireland. See Edw. Crust. vol. iii. p. 534, for genus *Ammothea*.

habiting only the extreme southern coast of England. One species—*Xantho rivulosus*—has a place in the Irish and not in the British catalogue, but Professor Bell informs me that he has seen English specimens.

Of the *Anomoura* there are five British species, all of which are likewise Irish, and to the latter are to be added four or five species of *Pagurus* above indicated: what the *P. erinaceus* of Mr. J. V. Thompson is I do not know, but the four species named by myself are very distinct from each other, and unknown as British: whether they be all undescribed is yet to be determined. They were taken by Mr. Hyndman and myself when dredging in deep water in the loughs of Strangford and Belfast.

Of the twenty-six British *Macroura* * all but seven are recorded as Irish. Five of these—*Axia stirhynchus, Gebia stellata, G. deltura, Hippolyte Prideauxiana,* and *H. Moorii*—were known to Leach as from the south of Devonshire only: *Hippolyte Sowerbæi* was obtained at Newhaven, near Edinburgh; *Penæus trisulcatus* on the coast of Wales. Two species—*Pasiphæa sivado* and *Palæmon Leachii*—have a place in the Irish and not in the British list.

The Decapodous Crustacea alone, I have critically studied throughout; consequently, so far only can a particular comparison of the species of the two islands be instituted: indeed of the British species belonging to the following orders, from *Stomapoda* to *Pychnogonida* inclusive, no proper catalogue is extant, and were those now known brought together and compared with the Irish species, the result would, as in the instance of the *Annelida*, simply denote how many belonging to each island had been determined, without giving any idea, as in the better studied portions of the Invertebrata, of the number positively, of each locality, or relatively, of the one island to the other. The undetermined Irish species in my own collection are perhaps thirty in number.

ANNELIDA.

About one-half of the *Annelides* in this catalogue were known to Templeton (Mag. Nat. Hist. ix.); the remainder, with the exception of a very few indicated by myself (Annals Nat. Hist. v. 247, vii. 482, and xiii.), have been investigated by my friend Dr. Johnston of Berwick-upon-Tweed, who kindly undertook to describe the species collected on the Irish shores (Annals Nat. Hist. v. p. 168 and 305, and vol. xiii.). He has likewise favoured me with a very elaborate manuscript catalogue of all the British *Annelides* on record with their numerous synonyma, and which it is but proper to mention, was drawn up with especial reference to a comparison of the British and Irish species in this Report. But, it is to be hoped that this catalogue will serve as the foundation of a work on the subject by Dr. Johnston.

ANNELIDA. Order 1. APODA. Tribe *Nemertina*.	Distribution. North.	East.	West.	South.
Gordius aquaticus, *Lin.*†	*			
Borlasia? alba, *Thomp.*, MSS. (I.)	*			
Lineus longissimus, *Sow.*; Nemertes Borlasii, *Cuv.*	*	*	*	

* In this number the species published by Mr. Harry Goodsir in the Edinburgh Philosophical Journal, vol. xxxiv., are not included, as he does not feel certain that they should be brought under *Macroura*.

† That little trouble has yet been taken to ascertain the distribution of the Irish *Annelides* is indicated in connection with the first species named, which doubtless is not confined to the north.

Order 1. Apoda.

Tribe *Nemertina*.

Species	North.	East.	West.	South.
Meckelia trilineata; Carinella trilineata, *Johnst.* Mag. Nat. Hist. vol. vi. p. 232. f. 24	*			
Prostoma gracilis, *Johnst.* (sp.); Nemertes grac., *Johnst.* Mag. Zool. and Bot. vol. i. p. 534. t. 17. f. 1.	*			
„ lactiflorea, *Johnst.* (sp.); Nem. lac., *Johnst.*, Mag. Zool. and Bot. vol. i. p. 535. t. 17. f. 2.	*			
„ armatum, *Templeton*, Mag. Nat. Hist. vol. ix. p. 236. f. 29. (I.)	*			
Planaria vittata, *Mont.*, Linn. Trans. vol. xi. p. 25. t. 5. f. 3.	*	...	*	
„ tremellaris, *Mull.*, Zool. Dan. (I.)	*	...	*	
„ stagnalis, *Mull.*, *Temp.* (I.)	*			
„ fusca, *Pall. Id.*	*			

Tribe *Hirudina*.

Species	North.	East.	West.	South.
Phylline hippoglossi, *Mull.* (sp.)	*			
Erpobdella tessulata, *Mull.* (sp.)	...	...	*	
Glossipora complanata, *Lin.* (sp.) ⎫ „ crenata ⎬ one species „ tuberculata. ⎭	*			
„ hyalina, *Mull.* (sp.); Clepsina hyal., Ann. Nat. Hist. vol. ix. p. 15. pl. 1. f. 20	*			
„ bioculata, *Mull.* (sp.); Hirudo stagnalis, *Linn.*	*			
Piscicola geometra, *Lin.* (sp.)	*			
„ percæ, *Temp.* (sp.); Ichthyobdella percæ, *Temp.*, Loud. Mag. Nat. Hist. vol. ix. p. 236. f. 28. (I.)	*			
„ marina, *Thomp.* MSS. (I.)	*			
Pontobdella muricata, *Lin.* (sp.)	*			
„ spinulosa, *Leach*, "probably not distinct from last," *Dr. J.*	*			
Hæmopsis sanguisuga, *Merr.* (sp.) *Lin.* (sp.)	*			

Tribe *Lumbricina*.

Species	North.	East.	West.	South.
Nais vermicularis, *Mull.* (I.)	*			
„ serpentina, *Mull.*	*			
Stylaria lacustris, *Lin.* (sp.)	*			
Tubifex rivulorum, *Lam.*; Lumbricus tubifex, *Mull.*	*			
Lumbricus lineatus, *Mull.*	...	...	...	*?
„ pellucidus, *Temp.*, Loud. Mag. Nat. Hist. vol. vii. p. 131. f. 27. (I.) ⎫ „ Clitellio minutus, *Temp.*, Loud. Mag. Nat. Hist. vol. ix. p. 235. ⎭ one species	*			
„ omilurus, *Temp.*, Loud. Mag. Nat. Hist. vol. ix. p. 235. (I.)	*			
„ lividus, (I.). „ „ „ „ „	*			
„ gordianus, (I.) „ „ „ „ „	*			
„ zanthurus, (I.) „ „ „ „ „	*			
„ annularis, (I.) „ „ „ „ „	*			
„ terrestris, *Lin.*	*	*	*	*
Cirratulus medusa, *Johnst.*, Mag. Zool. and Bot. vol. ii. p. 71. t. 3. f. 7-12.	...	*	*	
„ tentaculatus, *Mont.* (sp.)	*			
Trophonia Godsiri, *Johnst.*, Ann. Nat. Hist. vol. iv. p. 371. t. 11. f. 1-10.	*			

Order 2. Polypoda.

Tribe *Serpulina*.

Species	North.	East.	West.	South.
Pectinaria belgica, *Pall.* (sp.); Amphitrite auricoma, *Mull.*	*			
Sabellaria alveolata, *Lin.* (sp.)	*			
„ crassissima, *Penn.* (sp.)	*			
Terebella conchilega, *Pall.* (sp.)	*	...	*	

Order 2. Polypoda.

	Distribution. North.	East.	West.	South.
Tribe *Serpulina*.				
Terebella cirrhata, *Mont.*, Linn. Trans. vol. xii.	*?			
„ cristata, *Mull.* (sp.)	*			
Sabella reniformis, *Turt.* (sp.); Tubularia penicillus, *Mull.*, Zool. Dan. t. 89. f. 1, 2.	*			
„ penicillus, *Lin.* / Amphitrite ventilabrum, *Penn.* } one species	*			
„ carnea, *Johnst.*, Ann. Nat. Hist. vol. xiii.	*			
„ tubularia, *Mont.* (sp.); Serpula tubularia, *Mont.*	*	*	*?	*
Spirorbis communis, *Flem.*; Serpula spirorbis, *Linn.*	*	*	*	*
„ spirillum, *Lin.* (sp.)	*	*	...	*
„ granulatus, *Lin.* (sp.)	*	*		
„ minutus, *Mont.* (sp.)	...	*		
„ conicus, *Flem.* Edin. Ency. vol. vii. p. 68. pl. 205. f. 3.	*	...	*	
„ lucidus, *Mont.* (sp.)	*			
Serpula vermicularis, *Lin.*; S. intricata, *Lin.*; S. vermicularis, *Mull.*, *Mont.*	*	*		
„ triquetra, *Lin.* / „ contortuplicata, *Lin.* / „ contortus, spiralis, perversa of Brown, Illus. } one species	*	*	...	*
„ serrulata, *Flem.*, Edin. Ency. vol. vii. p. 67. t. 204. f. 8.; tricuspidata, *Sow.*	...	...	...	*
„ vitrea, *Fab.*?	*			
Filograna implexa, *Berk.*; Serpula minima, *Lam.* (*Temp.*)? *	*			
Ditrupa subulata, *Desh.* (sp.) (I.)	*			
Arenicola piscatorum, *Lam.*; Lumbricus marinus, *Lin.*	*			
Tribe *Nereidina*.				
Nereis viridis, *Johnst.*, Ann. Nat. Hist. vol. v. p. 171. f. 2.	*	...	...	*
„ pelagica „ „ „ 172. f. 3 and 4	*	...	...	*
„ Dumerilii „ „ „ 174. f. 5 and 6. (I.)	*			
„ fucata „ „ „ 175. f. 7. (I.)	*			
„ renalis „ „ „ 176. f. 8. (I.)	*			
„ longissima „ „ „ 178. f. 9. (I.)	*			
Syllis armillaris, *Mull.* (sp.)	*?			
Phyllodoce lamelligera, *Johnst.*, Ann. Nat. Hist. vol. iv. p. 225. t. 7. f. 1–3.	*			
„ viridis „ „ „ iv. p. 228. t. 6. f. 11–15.	...	...	...	*?
Bebryce peripatus, *Johnst.* MSS.				
Nephtys margaritacea, *Johnst.*, Loud. Mag. Nat. Hist. vol. viii. p. 341. f. 33.	*			
Spio calcarea, *Temp.*, Loud. Mag. Nat. Hist. vol. ix. p. 234. f. 27. (I ?) / „ seticornis, *Penn.* } one species	*			
Sigalion boa, *Johnst.*, Ann. Nat. Hist. vol. ii. p. 439.	*			
Polynoe squamata, *Johnst.*, Ann. Nat. Hist. vol. ii. p. 432. and v. p. 307.	*	...	*	
„ cirrhata „ „ „ p. 434. „ / „ Halithæa clava, *Temp.*, Mag. Nat. Hist. *Ibid.*	*	...	*	
„ scolopendrina „ „ „ vol. v. p. 307.	*			
Aphrodita aculeata, *Lin.*	*	*	*	
„ hystrix, *Sav.*	...	...	...	*
***Annelida*?**				
Campontia eruciformis, *Johnst.*, Loud. Mag. Nat. Hist. vol. viii. p. 179. f. 18.	*			

According to Dr. Johnston's catalogue, there is in the tribe *Nemertina*, one genus—*Dalyellia*, Flem.—known as British and not as Irish. Of twenty-nine British species seven are Irish; in addition to which are four—*Borlasia? alba*, *Prostoma armatum*, *Planaria stagnalis* and *P. tremellaris*—unnoticed as British.

* Templeton gives "*Serpula filiformis*, figured in Rees's Cyclop." without further remark. It is noted as a fossil species in Morris's Catal. Brit. Foss.

In the tribe *Hirudina* are four British genera unknown as Irish—*Udonella*, Johnst., *Malacobdella*, Blain., *Tristoma*, Cuv., *Hirudo**. Of the eighteen British species nine are Irish, and in addition to the latter are *Piscicola percæ* and a new species of *Piscicola* † which is marine.

In *Lumbricina*, there is but one genus, *Travisia*, Johnst., unknown as Irish. Of the seventeen British species, eight are Irish, to which seven unrecorded as British are to be added‡.

The tribe *Serpulina*§ contains one British genus—*Othonia*, Johnst.—unknown as Irish, but as such only, the genus *Ditrupa*, Berk.‖, is recorded. Of the fifty-three British species, twenty-two are described as Irish, in addition to which is the *Ditrupa subulata*.

Under *Nereidina* are nine British genera, *Eunice*, Schweig., *Onuphis*, Aud. and Edw., *Myriana*, Aud. and Edw., *Psamathe*, Johnst., *Ioida*, Johnst., *Glycera*, Lam., *Leucodore*, Johnst., *Nerine*, Johnst., *Pholoe*, Johnst., not included in the Irish catalogue. Of forty-five British species, fourteen are recorded as Irish, in addition to which are five undescribed as British, viz. *Nereis Dumerilii*, *N. fucata*, *N. renalis*, *N. longissima*, *Spio calcarea* (*S. seticornis*, Penn?).

Of doubtful *Annelides* Dr. Johnston enumerates four species, belonging to as many genera; these are *Campontia*, *Branchiarius*, Mont., *Diplotis*, Mont., *Derris*, Adams: the first only is known as Irish.

The whole of the recorded *Annelides* of Great Britain according to Dr. Johnston's catalogue are 167 species: the number known as Irish is 80¶. These numbers are useful only in denoting the species already known as indigenous to the respective islands, and give no idea of the number of species inhabiting our coasts and inland waters. In a forenoon's search several species might be added to either catalogue. About one-third of the British species were made known by Dr. Johnston, nearly all of which were previously undescribed.

FORAMINIFERA.

The native *Foraminifera* were included in the catalogues of Irish "Testacea" published by Capt. Brown and Dr. Turton, whose species have nearly all come under my own observation. The additional species, obtained and determined by Templeton and Mr. W. H. Harvey, were published in the Annals of Natural History, vol. v. p. 10, and those by Mr. Hyndman and myself will appear in vol. xiii. of the same work.

	Distribution.			
	North.	East.	West.	South.
Spirolina carinatula; Naut. carin., *Mont.*	...	...	*	
Renoidea rotundata, *Brown*, Illus. pl. 1. f. 14 and 15.	...	*	*	
„ glabra, *Brown*, Illus. pl. 1. f. 20, 21	...	*		
„ oblonga, *Brown*, „ f. 16, 17**	...	...	*	

* As now limited, *Hir. medicinalis* is the only British species.

† Dr. Johnston has since informed me that he likewise has an undescribed marine *Piscicola*.

‡ These six are earthworms of the genus *Lumbricus* (see preceding catalogue) described by Templeton, with whom I agree in constituting them distinct species, but whether they be described as such by other authors I am not aware.

§ The genus *Lobatula* included in this tribe by Dr. Johnston is omitted here, but brought in under *Foraminifera*.

‖ *D. subulata* only is brought under this genus in Dr. Johnston's catalogue.

¶ Many undetermined species are in my collection.

** In the second edition of Brown's Illustrations (of which a few parts are published) the term *Renoidea* is restricted to *oblonga*: the *Ren. glabra* and *Ren. rotundata* are placed in D. Orbigny's genus *Triloculina*.

FORAMINIFERA.

		Distribution. North.	East.	West.	South.
Polystomella crispa; Nautilus crispus, *Lin.*			*	*	
Lenticulina calcar	*Nautilus*, Mont. with specific names here used			*	
„ lævigatula				*	
„ depressula.			*		
Nonionina umbilicatula			*		
Rotalia beccarii.			*		
„ beccarii-perversus			*		
„ inflata			*		
Lobatula vulgaris; Serpula lobata, *Mont.*			*	*	
Vermiculum intortum; Nautilus, *Mont.*		*	*	*	*
„ oblongum, *Mont.*		*	*		
„ subrotundum, *Mont.*			*		
Lagenula striatula; Vermiculum str., *Mont.*		*			
„ globosa, *Flem.*		*			
„ lævis, *Flem.*				*	
Nodosaria legumen; Naut. leg., *Lin.*, *Mont.*			*	*	
„ recta; Naut. rec., *Mont.*				*	
Nautilus pulchella, *Temp.* Ann. Nat. Hist. vol. v. p. 99. (I.)		*			
„ dentatus, „ „ „ „ (I.)		*			

All the *Foraminifera* of the preceding list, except the two species described by Mr. R. Templeton, are known as British, and include about the one half of those brought together in Fleming's 'British Animals,' in 1828*. In Brown's 'Illustrations' seven species designated as new are figured:—three of these have now a place in the Irish catalogue. Mr. Macgillivray has in the present year added eight British species†.

ENTOZOA.

A catalogue of the species of Irish *Entozoa* known to Templeton appeared in the ninth volume (p. 238–240) of Loudon's Magazine of Natural History. In the second and third volumes of the new series of the same work conducted by Charlesworth, Dr. J. L. Drummond published a series of articles on the subject, and in the fourth volume (p. 240 and p. 343) will be found a paper from Dr. Bellingham‡, in which the species of *Filaria, Trichosoma, Trichocephalus, Oxyurus* and *Cucullanus*, which had come under his observation in Dublin, are recorded: also a notice of four species which occurred to him in the dissection of a sun-fish (*Orthagoriscus mola*). A remarkably copious manuscript catalogue of the *Entozoa* observed by Dr. Bellingham, has by his kindness been placed in my hands, and I shall give it just in the order (though much abbreviated)§ in which it has been com-

* The "*Nautilidæ*" of that work are all now considered *Foraminifera*, except *Spirula australis* (a cephalopodous mollusk), *Orthocera imperforata, O. trachea*, and *O. glabra*. The last three come under the genus *Cæcum*, Fleming, *Brocus*, Brown, *Odontidium*, Philippi.

† In Morris's 'Catalogue of British Fossils' just published, a great addition is made to the number heretofore known of the extinct species of *Foraminifera*.

‡ Dr. B. has likewise published some papers in the Dublin Medical Journal and Dublin Medical Press on this subject.

§ The notes necessarily omitted here, are the most valuable portion of the catalogue, recording as they do the whole of the various animals in which upwards of 220 species of *Entozoa* were found by the author. These notes will be published in the thirteenth vol. of the Annals of Natural History.

municated, adding within brackets in their proper places the species noticed by other naturalists, so as to present at one view the whole of the *Entozoa* known as Irish. Dr. Drummond has also contributed several species which were not treated of in his published papers. Dr. Bellingham remarks, "In furnishing this list of the indigenous *Entozoa*, I wish it to be understood that I have only inserted the species discovered and examined by myself, with the exception of two or three forwarded to me by my friends. The classification is that of Rudolphi, whose names for the species are adopted throughout unless otherwise expressed."

ENTOZOA.

Order Cystica.

Cysticercus fasciolaris.
,, tenuicollis.
,, cellulosa.
[,, ,, *Temp.* Mag. Nat. Hist. vol. ix. p. 240.]
,, pisiformis.
[,, hydatigena, *Pall.* (sp.), Temp. M. N. H. vol. ix. p. 240.]
[Coenurus cerebralis, *Gm.* (sp.), Temp. M. N. H. vol. ix. p. 240.]
[Echinococcus humanus, *Ed.*, Temp. M. N. H. vol. ix. p. 240.]
Anthocephalus elongatus.
,, granulum.
[,, paradoxus, *Drum.* Charlesworth, M. N. H. vol. ii. p. 655.]
[,, rudicornis, *Drum.* id. vol. iii. p. 227.]

In this Order are a *Cysticercus* and five species of *Anthocephalus* undetermined by Dr. Bellingham.

Order Cestoidea.

Tænia expansa.
,, pectinata [Dr. D.]*.
,, lanceolata [Dr. D.].
,, cucumerina.
,, filicollis.
,, nasuta.
,, sphærophora [Dr. D.].
,, lævigata.
,, cyathiformis.
,, infundibuliformis.
,, setigera.
,, platicephala.
,, angulata.
,, lævis.
,, æquabilis.
,, tenuirostris.
,, filum.
,, elliptica.
,, gracilis.
,, pusilla?
,, farciminalis.
,, stylosa.
,, solium.
[,, ,, *Temp.* M. N. H. ix. 239.]
,, serrata.
,, crassicollis.
,, sinuosa [Dr. D.].
,, inflata.
,, porosa?
[,, vulgaris, *Lin.*, Temp. M. N. H. ix. 239.]
Botriocephalus claviceps.
,, latus, *Brems.*
,, proboscideus.
,, infundibuliformis?
,, microcephalus.
,, solidus.
,, punctatus.
[,, ,, *Drum.* M. N. H. new series, ii. p. 574.]
,, nodosus.
,, macrocephalus.
,, tumidulus.
,, coronatus.
,, corollatus [Dr. D.].
,, paleaceus.
[,, auriculatus, *Rud.* Drum. MS.]
[,, crassiceps, *Rud.* Drum. MS.]
Ligula sparsa.
Scolex polymorphus.
[,, ,, *Drum.* M. N. H. new series, vol. iii. p. 229.]
[Tetrarhynchus grossus, *Rud.*, Drum. M. N. H. new series, ii. 571.]
[,, solidus, *Drum.* M. N. H. new series, vol. ii. p. 573.]
[Tetrantarus (*Temp.*) truttæ, *Temp.* M. N. H. vol. ix. p. 239. fig. 32.]

* Species so marked noted in Dr. Drummond's MSS. in addition to Dr. Bellingham's.

In this Order are twenty-three species of *Tænia* and five of *Botriocephalus* undetermined by Dr. Bellingham.

Order Trematoda.

Pentastoma tænioides.
Distoma hepaticum.
[Distoma hepaticum, *Temp*. M. N. H. vol. ix. p. 239.]
,, tumidulum.
,, oxycephalum.
,, fulvum.
,, clavigerum.
,, cylindraceum.
,, gibbosum?
,, appendiculatum.
,, rufoviride.
,, globulus.
,, reflexum? *Creplin*.
,, excisum.
,, trigonocephalum.
Distoma echinatum.
,, militare.
,, spinulosum.
,, scabrum.
,, contortum.
,, nigro-flavum*.
[,, anguillæ, Zool. Dan. t. 91? Drum.]
Amphistoma longicolle.
,, macrocephalum.
,, isostomum.
,, gracile.
,, cornu.
,, sphærula.
Monostoma attenuatum.
,, verrucosum†.

In this Order are ninety-nine species of *Distoma* and three of *Amphistoma* undetermined by Dr. Bellingham.

Order Acanthocephala.

Echinorhynchus angustatus [Dr. D.].
,, transversus.
,, acus.
[,, ,, *Drum*. M. N. H. new series, ii. 515. E. candidus and E. lineolatus, *Mull*. Zool. Dan. same as E. acus, *Drum*. id.]
,, filicollis.
[,, ,, *Drum*. M. N. H. new series, iii. 66. E. sphærocephalus same as E. filicollis? *Drum*. id. p. 67.]
Echynorhynchus tereticollis.
,, nodulosus.
,, strumosus.
,, striatus?
,, versicolor.
[,, ,, *Drum*. M. N. H. new series, iii. 65.]
,, hystrix.
[,, ,, *Drum*. M. N. H. new series, iii. 63.]

In this Order are five species of *Echinorhynchus* undetermined by Dr. Bellingham.

Order Nematoidea.

Ascaris lumbricoides.
[,, ,, *Temp*. M. N. H. ix. 239.]
,, megalocephala, *Cloquet*.
,, vesicularis.
,, inflexa.
,, constricta.
,, rotundata.
,, osculata.
,, acuminata.
,, marginata.
,, triquetra.
,, mystax.
Ascaris depressa.
,, ensicaudata.
,, nigrovenosa.
,, sacus.
,, angulata.
,, vermicularis.
[,, ,, *Temp*. M. N. H. ix. 239.]
,, obvelata.
,, maculosa.
,, dentata.
,, brevicaudata.
,, spiculigera [Dr. D.].

* "Two more species of *Distoma* may be here mentioned; *D. flexuosum* from the small intestines of a Mole, *Talpa Europea*, and another (species undetermined) from the œsophagus of the common Snake, *Natrix torquata*—both Mole and Snake were brought from England."—Dr. Bellingham.

† "*Monostoma octonatum*, found in the small intestines of a Mole (*Talpa Europea*) from England, may here be noticed."—Dr. Bellingham.

Order Nematoidea.

Ascaris variegata.
,, obtusocaudata.
,, labiata.
,, capsularia [Dr. D.].
,, heteroüra, *Creplin*.
,, cuneiformis.
,, clavata [Dr. D.].
,, collaris.
,, tenuissima.
,, succisa.
,, alata, *Bellingham*, Dublin Medical Press, vol. i. (head figured.)
[,, simplex, *Rud.*, Drum. MS.]
[,, rigida, ,, ,, ,,]
[,, crenata, ,, ,, ,,]
Strongylus tubifex.
,, contortus.
,, retortæformis [Dr. D.].
,, trigonocephalus.
,, tetragonocephalus.
,, suis.
,, trachealis; Syngamus trach., *Siebold*.
Spiroptera strumosa.
,, anthuris.
Spiroptera cystidicola [Dr. D.].
,, leptoptera.
Cucullanus elegans.
,, faveolatus.
[,, platessæ, *Reinh.*, Drum. M. N. H. new series, ii. 519.]
[,, marinus, *Rud.*, Drum. MS.]
Oxyurus curvula.
[,, ,, *Temp*. M. N. H. ix. 238.]
,, ambigua.
[,, gadi, *Temp*. ibid. fig. 31.]
Trichocephalus dispar.
[,, ,, *Temp*. M. N. H. ib.]
,, crenatus.
,, nodosus.
Trichosoma obtusum?
,, inflexum?
,, longicolle.
,, plica.
Filaria attenuata.
[,, capsularia, *Rud.*, Drum. M. N. H. new series, iii. 230.]
[Trichina spiralis, *Owen*, Allman, Microscopic Journal, vol. ii. p. 94.]

In this Order are nine species of *Ascaris*, two of *Strongylus*, six of *Spiroptera*, nine of *Trichosoma*, and three of *Filaria* undetermined by Dr. Bellingham.

The Irish species given in the preceding catalogue so far outnumber the British species known, that the usual comparison is uncalled for. Dr. Bellingham remarks, "The little attention which these animals have attracted in these countries will be apparent from the fact, that in the only works which contain lists of the British species of *Entozoa*, viz. Pennant's British Zoology, and Turton's British Fauna, but twenty-eight are described as indigenous, and four of these are noticed twice under different names, leaving but twenty-four distinct species; while in the limited opportunity which I have had, I have discovered and preserved upwards of 220 species, and several of these occurred in six, others in ten, and one species in as many as fifteen different animals." The number of Irish species determined by Dr. Bellingham is 143*; of species undetermined, but brought under their respective genera†, eighty:—from the many works consulted, but in vain, for these latter, there is little doubt that the greater portion must be undescribed. Dr. Drummond too informs me that he has obtained many *Entozoa* which he believes to be new. The species recorded by Dr. Bellingham‡ were procured in Dublin; those by Templeton and Dr. Drummond in Belfast.

* Three species as indicated in a foot note are from British animals.

† Dr. Bellingham has some *Entozoa* which he cannot refer to any genus, and knows of several species having been obtained in Dublin, which are not included in his catalogue.

‡ *Botriocephalus solidus* is an exception, having been found by Dr. G. J. Allman in a *Gasterosteus aculeatus* taken in the co. of Cork—in specimens of this fish captured in the neighbourhood of Dublin Dr. Bellingham could never find this Entozoon.

ECHINODERMATA.

The Irish species of *Echinodermata* known to Templeton were published in the ninth volume of Loudon's Magazine of Natural History, and subsequent additions were contributed by myself to the Annals of Nat. Hist. vol. v. (p. 99 and 245) and vol. xiii.

ECHINODERMATA.	Distribution.			
	North.	East.	West.	South.
Order Pinnigrada.—*Crinoideæ.*				
Comatula rosacea, *Link.* (sp.)	*	*	...	*
Order Spinigrada.—*Ophiuridæ.*				
Ophiura texturata, *Lam.*	*	*	...	*
„ albida, *Forbes*	*	*	*	
Ophiocoma neglecta, *Johnst.* (sp.)	*	*	*	
„ Ballii, *Thomp.*	...	*		
„ filiformis, *Mull.*	...	...	*	*
„ brachiata, *Mont.* (sp.)	*			
„ granulata, *Link* (sp.)	*	*		
„ bellis, *Link* (sp.)	*	*	*	*
„ rosula, *Link* (sp.)	*	*	*	*
„ minuta, *Forbes*	*	...	...	*
Order Cirrhigrada.—*Asteriadæ.*				
Uraster glacialis, *Lin.* (sp.)	*	*	*	*
„ rubens, *Lin.* (sp.)	*	*	*	*
Uraster violacea, *Mull.* (sp.)	*	...	*	*
„ hispida, *Penn.* (sp.)	*			
Cribella oculata, *Penn.* (sp.)	*	*	*	*
„ rosea, *Mull.* (sp.)	...	...	...	*
Solaster endeca, *Lin.* (sp.)	*	*	...	*
„ papposa, *Lin.* (sp.)	*	*	...	*
Palmipes membranaceus, *Retz.*	*	...	...	*
Asterina gibbosa, *Penn.*	*	*	*	*
Goniaster Templetoni, *Thomp.*	*	...	...	*
Asterias aurantiaca, *Lin.*	*	*	*	*
Luidia fragilissima, *Forbes*	...	...	...	*
Order Cirrhi-Spinigrada.—*Echinidæ.*				
Echinus sphæra, *Mull.*	*	*	*	*
„ miliaris, *Leske*; var. E. pustulatus, *Agass.*	*	*	*	*
„ Flemingii, *Ball*	...	...	...	*
„ lividus, *Lam.* (I.)	...	...	*	*
Echinocyamus pusillus, *Mull.* (sp.)	*	*	...	*
Spatangus purpureus, *Mull.*	*	*		
Amphidotus cordatus, *Penn.* (sp.)	*	*	*	*
„ roseus, *Forbes*	*	*	*	*
Order Cirrhi-Vermigrada.—*Holothuriadæ.*				
Psolus phantapus, *Lin.* (sp.)	*			
Cucumaria pentactes, *Mull.* (sp.)	*			
„ communis, *Forbes & Goodsir*	*	...	...	*
„ fusiformis, *Forbes & Goodsir*	*			
„ Drummondii, *Thomp.* (I.)	*			
„ Hyndmani, *Thomp.* (I.)	*	...	*	
Ocnus brunneus, *Forbes*	*			
„ lacteus, *Forbes & Goodsir*	*	...	*	*?

	Distribution.			
	North.	East.	West.	South.
Order Cirrhi-Vermigrada.—*Holothuriadæ*.				
Thyone papillosa, *Mull.* (sp.)	*	...	*	
„ Portlockii, *Forbes* (I.)	*	* ?		
Chirodota digitata, *Mont.* (sp.)?	*			
Order Vermigrada.—*Sipunculidæ*.				
Syrinx papillosus, *Thomp.* (sp.)	*	...	*	
Sipunculus Bernhardus, *Forbes*	*	*	*	
„ Pallasii, *Thomp.* MSS. (I.)	*			
Priapulus caudatus, *Lam.*	*			
Thalassema Neptuni, *Gærtn.* (sp.)	*			

In the arrangement and nomenclature of the preceding catalogue, the excellent work of Professor E. Forbes on the British *Echinodermata* is implicitly followed. The fullness with which the subject is treated in that work—to which all the information on the Irish species was contributed*,—renders a few words only desirable here on the distribution of the species as yet unknown to our Fauna.

Of the twenty-nine † species of British "Starfishes"—*Crinoideæ, Ophiuridæ* and *Asteriadæ*—all but five are recorded as Irish. These are *Oph. punctata* and *Oph. Goodsiri,* both of which were first described in Forbes's Brit. Echin.; the former has been taken only at Anstruther in Fifeshire; the latter there and at Shetland. *Astrophyton scutatum* and *Goniaster equestris* are both very rare, but have occurred at a few localities from north to south of Great Britain. Of *Goniaster Abbensis* (Forbes, Annals Nat. Hist. vol. xi. April 1843,) but a single individual has yet been met with, and as its name indicates, at St. Abb's Head.

Of the eleven species of British *Echinidæ,* four are unknown to Ireland, but, one species—*E. lividus*—found on the western and southern coasts of the latter island, and unknown as British, makes our number eight. Of the desiderata, two—*Cidaris papillata* and *Echinarachnius placenta*—are extremely rare, and have been taken only in Shetland; *Echinus neglectus* there and in Orkney. *Brissus lyrifer* (first described in Forbes's Hist. Brit. Echin.) has been obtained only in the estuary of the Clyde.

Of the twelve British species of *Holothuriadæ,* eight are known as Irish, and three—*Cuc. Drummondii, Cuc. Hyndmani* and *Thyone Portlockii*—discovered on the coast of the latter country and unknown as British, make the Irish species eleven in number. Of our desiderata, two species—*Cucumaria hyalina* and *Cuc. fucicola*—are known only to Shetland; *Psolinus brevis* to the same locality and the Kyles of Bute; *Cucumaria frondosa* to the same and the coast of Fife.

Of the eight species of British *Sipunculidæ* four are known as Irish, in addition to which is the *Sipun. Pallasii,* that cannot be announced with certainty as British. Our desiderata are so rare that they have each been obtained in a single locality only on the British coast, namely, *Syrinx nudus* (with certainty) and *Syr. Harveii* at Teignmouth in Devonshire; *Sipunculus Johnstoni* at Berwick-upon-Tweed; *Echiurus vulgaris* at St. Andrews.

* Four species have since been added.

† The original descriptions of two species—*Oph. Ballii* and *Goniaster Templetoni*—were drawn up from Irish specimens, and the first *Cribella rosea* noticed in the British seas was obtained off the south of Ireland.

ACALEPHA.

A catalogue of the *Acalepha* of Ireland known to Templeton was published in the ninth volume of Loudon's Magazine of Natural History; subsequently papers on the subject have been published by Mr. Patterson* and Mr. Hyndman†, and some additional species to our Fauna recorded by myself in the Zoological Proceedings for 1835, (p. 78)‡ and Annals of Natural History, vol. v. p. 248. Mr. R. Ball has, from observations made at Youghal and Dublin, contributed to our knowledge in this department.

ACALEPHA.	Distribution. North.	East.	West.	South.
Velella mutica, *Lam.* ? §	*	...	*	*
„ emarginata, *Thomp.* MSS. (I.)	...	...	...	*
Physalia pelagica, *Eschscholtz* (not *Lam.*‡)	...	...	...	*
Beroe cucumis, *Fabr.* (*Otho*)	*			
„ fulgens, *Macartney*	...	* ?		
Cydippe pileus, *Lin.*	*			
„ lagena, *Forbes*	*			
„ pomiformis, *Patterson*	*	*	...	*
Alcinoë Smithii, *Forbes*	*			
„ Hibernica; Bolina Hib., *Patterson* (I.)	*	*	...	*
Melicertum campanulatum, *Ehrenb.*	*			
Hippocrene Britannica, *Forbes*	*			
Sarsia tubulosa, *Lesson*; Oceania ? tubul. *Sars*	*			
Oceania papillata, *Mull.* (sp.); Medusa papil. Zool. Dan. (I.)	*			
Thaumantias hemisphærica, *Mull.* (sp.)	*			
„ pileata, *Forbes*	*			
„ Thompsoni, *Forbes* (I.)	...	...	*	*
Ephysa simplex, *Penn.* (sp.) ‖	*			
„ hemisphærica, *Templeton* ¶ (I.)	*			
Obelia vitrea, *Penn.* (sp.); Piliscelotus vitreus, *Templeton*	*			
? Ocyroe ? cruciata, *Temp.* (I.)	*			
Chrysæora tuberculata, *Penn.* (sp.) **	*			
Aurelia aurita, *Lin.* (sp.)	*	*	*	*
„ bilobata, *Forbes*, MS. (I.)	*			
Rhizostoma Cuvieri, *Peron*; Med. undulata, *Penn.*	*	...	* ?	
Cyanæa Lamarckii, *Peron.*	...	...	*	
„ capillata, *Lin.* (sp.); " C. inscripta, *Temp.* young" (*Forbes*)	*	...	*	
? Æquorea ? radiata, *Temp.*	*			
? Callirhoe ? dubia, *Temp.*†† (I.)	*			
" Medusa scintillans," *Macartney* ‡‡	*			
Diphya elongata, *Hyndman*, Ann. Nat. Hist. vol. vii. (I.) §§	*	...	*	
Apolemia ? Gettiana, *Hyndman*, (I.) ‖‖	*			

* Edin. Phil. Journ., Jan. 1836. Trans. Roy. Irish Acad. vol. xix. part 1.

† Ann. Nat. Hist. vol. vii. p. 164. and vol. xiii.

‡ *Physalia pelagica* only is here noticed; two fine examples of this species have at different times been obtained at Youghal by Miss Ball.

§ A species of *Velella* is not uncommonly found thrown ashore on the north and west coasts, but being generally in an injured state, its species is uncertain. The *V. emarginata* is in all respects different from, and twice the size of the ordinary species. It was obtained on the coast of Cork some years ago by Dr. Geo. J. Allman.

‖ " Probably as Cuvier suggests, some species in a mutilated state." *Forbes.*

¶ " Perhaps a young state of *Aurelia.*" *Forbes.*

** " This and the preceding are badly observed species." *Forbes.*

†† " Of doubtful position, but apparently a good species." *Forbes.*

‡‡ " Probably the fry of some species." *Forbes.* Lesson names it *Thaumantias lucida*, p. 335.

§§ Among shell-sand collected at Bundoran on the western coast by Mrs. Hancock, and sent to Mr. Hyndman, several *Diphyæ* (apparently *D. elongata*) were met with.

‖‖ This species will be described in the Annals of Natural History.

Professor Edw. Forbes, who has bestowed more attention on the *Acalepha* than any British author, and successfully studied the species in a living state, has kindly contributed for my use on the present occasion a catalogue of the native species, in which those observed by him when dredging in various parts of the Irish coast are noted: some of these have already been published in the Reports of the British Association for 1839 (p. 85, Transactions of Sections), and Annals of Nat. Hist. vol. vii. p. 81. The recorded species of British and of Irish *Acalepha* are about the same in number; the latter exclusively (as yet observed) are above indicated in the usual manner: those known as British and not as Irish, according to Professor Forbes's catalogue, are the following:—

Cydippe Flemingii, *Forb.*
Rataria (*Esch.*) pocillum, *Mont.* (sp.)
Alcinoe rotunda, *Forbes & Goodsir.*
Dianæa? Bairdii, *Johnst.* Mag. Nat. Hist. vol. vi.
Thaumantias punctata, *Forbes,* Ann. Nat. Hist. vol. vii.
" Sarnica, " " "
"Cyanæa" coccinea, *Davis,* Ann. Nat. Hist. vol. vii. p. 234. pl. 2. (Gen. Oceania.)
"Geryonia" octona, *Flem.* Brit. Anim. (Gen. Oceania.)
Aurelia granulata, *Esch.*
" purpurea, *Penn.*
Cassiopea lunulata, *Penn.*
"Eulimena" quadrangularis, *Flem.* Brit. Anim. (probably a Beroe.)

ZOOPHYTA.

The Zoophytes of Ireland are well known. In Ellis's British 'Corallines' some species from the coast of Ireland are described; in the ninth volume of Loudon's Magazine of Natural History a complete catalogue of the native Zoophytes known to Templeton appeared; in the 'Zoological Researches' of Mr. John Vaughan Thompson is a "memoir" (5th) partly upon the subject; in the Annals of Natural History, vol. v. p. 249, and vol. vii. p. 481, additional species to the Irish Fauna are given by myself; in vols. vi. vii. and ix. of this work Mr. Hassall has very fully entered into the subject; in the Proceedings of the Royal Irish Academy for 1843*, and in a communication brought before the present meeting†, Dr. Geo. J. Allman has given the results of his investigation of the freshwater species.

The collections of Dr. J. L. Drummond and Mr. Hyndman from the north and north-east coast; of Mr. W. H. Harvey (communicated to me in 1834), Miss Ball, and Mr. R. Ball from the Dublin coast; of the two last-named from Youghal (co. Cork); of Mrs. Hancock from Ballysodare (co. Sligo), and others of less extent have added much—in addition to those of the naturalists who have written upon the subject—to our knowledge of the native species.

To my kind friend Dr. Johnston I am indebted for a manuscript catalogue of the British Zoophytes as known to him at the present time: the nomenclature and synonyma of the following list are taken from it, as are, also, the data on which the concluding remarks are founded.

* The title of this paper is "On the Muscular System of *Paludicella articulata* and other Ascidian Zoophytes of fresh water."
† See present volume.

ZOOPHYTA*.

Order Hydroida.

	Distribution. North.	East.	West.	South.
Clava multicornis; Coryne squamata, *Lam.*	*	...	*	
" capitata; Echinochorum clavigerum, *Hass.*	*?	*		
" minuticornis; Hydra corynaria, *Temp.*	*			
Coryne pusilla, *Gært.*; C. glandulosa, *Lam.*	*	...	*	
Eudendrium rameum; Tubularia ramea, *Pall.*	...	*		
,, ramosum; Tub. ramosa, *Lin.*	*	*	*	*
Tubularia indivisa, *Lin.*	*	*	...	*
,, larynx, *Ellis*	*	*		
,, muscoides, *Lin.*	*	*		
Thoa halecina, *Lamx.*	*	*	*	
,, Beanii, *Johnst.*	*	*		
,, muricata, *Johnst.*	*			
Sertularia polyzonias, *Lin.*	*	*	...	*
,, rugosa, *Lin.*	*	*		
,, rosacea, *Lin.*	*	*	...	*
,, pumila, *Lin.*	*	*	*	*
,, pinaster, *Ellis*; S. margareta, *Hass.* (*W. T.*)	*	*		
,, tamarisca, *Lin.*	*	*		
,, abietina, *Lin.*	*	*		
,, filicula, *Ellis*	*	*		
,, operculata, *Lin.*	*	*	*	*
,, argentea, *Ellis*	*	*	*	*
,, cupressina, *Lin.*	*	*	*	*
Thuiaria thuja, *Flem.*	*			
,, articulata, *Flem.*	*	*		
Antennularia antennina, *Flem.*; A. ramosa	*	*	*	*
,, arborescens, *Hass.* (probably not distinct from last.)	...	*		
Plumularia falcata, *Lam.*	*	*	*	
,, cristata, *Lam.*	*	*	*	*
,, pennatula, *Lam.*	...	...	...	*
,, pinnata, *Lam.*	*	*	*	*
,, setacea, *Lam.*; Sertularia Templetoni, *Flem.* (*W. T.*)	*	*	*	*
,, Catharina, *Johnst.*	...	*		
,, myriophyllum, *Lam.*	...	*	...	*
,, frutescens, *Flem.*	...	*	...	*
Laomedea dichotoma, *Lamx.*	*	*	*	*
,, geniculata, *Lamx.*	*	*	*	*
,, gelatinosa, *Lamx.*	*	*	...	*
Campanularia volubilis, *Lam.*	*	*	...	*
,, integra, *Macgill.*	*			
,, syringa, *Lam.*	*	*		
,, verticillata, *Lam.*	*	*	...	*
,, dumosa, *Flem.*	*	*	*	*
Hydra viridis, *Lin.*	...	*	...	*
,, vulgaris, *Pall.*	*	*	...	*
,, fusca, *Lin.*	...	*		
,, verrucosa, *Temp.* (Allman makes this identical with H. fusca.)	*			
Cordylophora lacustris, *Allman.* (See present volume.) (I.)	...	*		

Order Asteroida.

	North.	East.	West.	South.
Virgularia mirabilis, *Lam.*	*			
Gorgonia anceps, *Pall.*	...	*?		
Alcyonium digitatum, *Lin.*	*	*		

* Before entering on the Zoophytes it may be mentioned that Templeton noticed ten species of *Vorticella* in the ninth volume of Loudon's Mag. Nat. Hist. (p. 420), of which three are described and figured as new.

	Distribution.			
	North.	East.	West.	South.
Order Helianthoida.				
Zoanthus Couchii, *Johnst.*	...	...	...	*
Caryophyllia Smithii, *Stokes*	...	*	*	*
Anthea cereus, *Johnst.*	*	*	*	
Adamsia maculata, *Forb.*; Actinia mac., *Adams*	*	*		
Actinia mesembryanthemum, *Ellis*	*	*	*	*
,, margaritifera, Temp. Loud. M. N. H. vol. ix. p. 304. f. 50. (I.)	*	...	*	
,, viduata, *Mull.*	...	...	*	
,, coccinea, *Mull.* (I.)	...	...	*	
,, bellis, *Ellis*	*	*		
,, gemmacea, *Ellis*	*	*		
,, dianthus, *Ellis*	*	*		
Lucernaria fascicularis, *Flem.*	*			
,, auricula, *Fabr.*	*			
Order Ascidioida.				
Serialaria lendigera, *Lam.*	*	*	...	*
Vesicularia spinosa, *Thomp.* (*J. V.*)	*	*	*	*
Valkeria cuscuta, *Flem.*	*	*	*	*
,, uva, *Flem.*	*	*		
,, pustulosa, *Johnst.*	*	*	...	*
Bowerbankia imbricata, *Johnst.*; B. densa, *Farre*, primary state = Sertularia imbricata, *Adams*; Valk. glomerata, *Colds.*: adult state	*	*	*	*
Lagenella repens, *Farre*	*	*		
Pedicellina echinata, *Sars.* (I.)	*	*	...	*
Crisea cornuta, *Johnst.*	*	*	*	
,, eburnea, *Lamx.*	*	*	*	*
,, luxata, *Flem.*; C. denticulata, *Edw.*	*	*	...	*
,, aculeata, *Hass.*	*	*		
Tubulipora patina, *Lam.*; Discopora verrucaria, *Flem.*	*	*	...	*
,, hispida, *Johnst.*; Discopora hisp., *Flem.*	*	...	...	*
,, flabellaris, *Johnst.*; Tubipora flab., *Fabr.*; T. lobulata, *Hass.*	*	*		
,, serpens; Tubipora serpens, *Lin.*; T. transversa, *Lam.*	*	*	*	*
,, obelia, *Johnst.*	*	...	...	*
Alecto ———?	...	...	...	*
Encratea chelata, *Lamx.*	*	*	*	*
Notamia loriculata, *Flem.*	*	*		
Hippothoa catenularia, *Flem.*	...	*	...	*
,, divaricata, *Lamx.*; H. lanceolata, *Gray*	*	*	*	*
Anguinaria spatulata, *Lam.*	...	*	...	*
Cellepora pumicosa, *Lin.*	*	*	*	*
,, ramulosa, *Lin.*	*	*	...	*
,, cervicornis, *Flem.*	*	...	...	*
Lepralia hyalina, *Johnst.*; β L. cylindrica, *Hass.*	*	*	*	*
,, Hassalli, *Johnst.* MSS.; Cellep. bimucronata, *Hass.*	...	*		
,, unicornis, *Johnst.*; L. coccinea, *Johnst.*	*	*	*	
,, pediostoma, *Hass.*; Flust. Hibernica, *Hass.*	...	*		
,, verrucosa, *Johnst.*; L. Johnstoni, *Bean*, MSS.	...	*		
,, biforis, *Johnst.*	*			
,, granifera, *Johnst.* MSS.	*?			
,, variolosa, *Johnst.*	*	*	...	*
,, immersa, *Johnst.*	*	*	*	*
,, punctata, *Hass.*	...	*		
,, nitida, *Johnst.*	*	*		
,, ciliata, *Johnst.*; B. utriculata, *Flem.*; β L. insignis, *Hass.*	*	*	*	*
,, spinifera, *Johnst.*; L. ciliata, *Hass.*	...	*		
,, coccinea; Cell. coccinea, *Mull.*	*			

Order Ascidioida.

	Distribution. North.	East.	West.	South.
Lepralia semilunaris, *Hass.*	...	*		
,, linearis, *Hass.* (I.)	*	*		
,, auriculata, *Hass.*	...	*		
,, ventricosa, *Hass.*	...	*		
,, tenuis, *Hass.* (I.)	...	*		
,, assimilis, *Hass.* (I.)	...	*		
,, ovalis, *Hass.**	...	*		
Membranipora pilosa; Flustra pil., *Lin.*	*	*	*	*
,, membranacea; Fl. memb., *Mull.*; Fl. tuberculata, *Johnst.*	*	*	*	*
Flustra foliacea, *Lin.*	*	*		
,, chartacea, *Gmel.*	...	*	...	*
,, truncata, *Lin.*	*			
,, carbasea, *Ellis & Solan.*	*?			
,, avicularis, *Sower.*	*	*	*	*
,, lineata, *Lin.*†	*	*	*	
Cellularia ciliata, *Pall.*	*	*	*	*
,, scruposa, *Pall.*	*	*		
,, reptans, *Pall.*	*	*	*	*
,, avicularia, *Ellis & Solan.*	*	*		
Acamarchis neritina (sp.), *Lin.*	*			
,, plumosa; Cellul. plum., *Pall.*; Sert. fastigiata, *Lin.*	*	*		
Farcimia salicornia; Cellul. sal., *Pall.*	*	*		
,, sinuosa, *Hass.*	*	*		
Alcyonidium gelatinosum; Alcyonium gel., *Pall.*	*	*	*	
,, hirsutum, *Flem.*	*	*	*	*
,, echinatum, *Flem.*	*	*	*	*
,, ? parasiticum, *Flem.*	...	*		
Cycloum hispium, *Fabr.* (sp.) Cycl. papillosum, *Hass.*; Flustra ? carnosa, *Johnst.*; Flustra spongiosa, *Temp.*	*	*	*	
Sarcochitum polyoum, *Hass.*	*	*		
Cristatella mucedo, *Cuv.*	...	*	...	*
Alcyonella stagnorum, *Lam.*	...	*		
Plumatella repens, *Lam.*	*	*	...	*
,, emarginata, *Allman* (I.)	...	*	...	*
,, fruticosa, *Allman* (I.)	...	*	...	*
Fredericella gelatinosa; Plumat. gel., *Flem.*, *Johnst.*	...	*	...	*
,, sultana; Tubularia sult., *Blumen.* "Identical with F. gelatinosa," *Allman*	...	*	...	*
,, dilatata, *Allman* (I.) (See present vol. or Annals, vol. xiii. p. 331.)	...	*	...	*
Paludicella articulata, *Gervais* (I.)	*	*		

Of the *Zoophyta Hydroida* there are fifty-two British species, five of which are not recorded as Irish: of these, three are each from a single locality—*Corymorpha nutans*, from Shetland; *Sertularia Evansii*, Yarmouth, and known only to Ellis; *Laomedea obliqua*, south of England? The others are *Sertularia pinnata*, of which nothing positive can be said, owing to the confusion in which the species is involved; *Sertularia nigra*, noticed on the east coast of Great Britain and in Cornwall. *Cordylophora lacustris*, a freshwater species discovered in the vicinity of Dublin by Dr. Geo. J. Allman, and for the reception of which he has constituted a new genus, has not been met with in Great Britain.

Ireland is very deficient in the *Zoop. Asteroida*, three only of the eight

* The preceding seven *Lepraliæ* have not been examined by Dr. Johnston.

† *Flustra distans*, Hass. not a veritable species.

British species having been found upon our coast: two of these eight—*Gorgonia placomus,* noted as from Cornwall (Ellis), and *Isis hippuris,* from the east of Scotland and Orkney—are considered by some authors as doubtful British species. The others are *Pennatula phosphorea,* for which the only localities particularized in Johnston's British Zoophytes are on the eastern coast of Scotland*; *Gorgonia verrucosa* from Cornwall, Devon, "Scotland;" *Gorgonia lepadifera* from Shetland and Aberdeenshire.

There are twenty British species of *Zoophyta Helianthoida,* including *Capnea sanguinea,* discovered in the Irish Sea near the Isle of Man by Professor Edw. Forbes. Nine of these have not been noticed on the Irish coast, and on the British, one only of the number has been found in more than a single locality, viz. *Lucernaria campanulata,* obtained at Torbay and Berwick. The others are the *Capnea* already mentioned; *Turbinolia borealis* and *Actinia intestinalis* from Zetland; *Anthea Tuedia* and *Actinia saxatilis* from Berwick; *Act. biserialis* from Guernsey; *Iluanthus Scoticus* from Loch Ryan.

The *Actinia margaritifera* and *Act. coccinea* found on the coast of Ireland, are unknown to the British catalogue.

The British species of *Zoop. Ascidioida* may be reckoned ninety-three in number†, after several species described as distinct have been made synonymous with others previously known; of these, twenty-eight have not yet been recorded as Irish:—several are yet unpublished as British. On the other hand, eight known as Irish have not a place in the catalogue of Great Britain; three are *Lepraliæ* described by Mr. Hassall; the *Pedicellina echinata* of Sars; *Plumatella emarginata, Plum. fruticosa* and *Fredericella dilatata* of Allman; *Paludicella articulata* of Gervais‡. Of the Irish desiderata seventeen species are each from a single British locality—*Beania mirabilis* and *Flustra Murrayana* from Scarborough; *Tubulipora penicillata, T. deflexa, T. trahens* and *T. hyalina*§ (described by Mr. Conch), from Cornwall, which is the only locality for *Retepora reticulata. Tubulipora truncata, Cellepora lævis,* and *Flustra setacea* have been obtained at Zetland. Pallas's habitat for *Notamia bursa*—"mare Anglicum"—should probably be more strictly a limited locality. *Lepralia trespinosa* is from Berwickshire; *Cellularia Hookeri* from Torquay; *Eschara fascialis,* Isle of Wight; *Lepralia reticulata,* Aberdeen. The remaining species respecting which localities have been published, are *Cellepora Skenei,* east coast of Great Britain, &c., from Northumberland to Zetland, and lately dredged off the Mull of Galloway by Capt. Beechey, R.N.; *Retepora cellulosa,* Shetland,Fulah and Scarborough; *Eschara foliacea,* Sussex and the south coast of England.

AMORPHOZOA.

A catalogue of the Irish Sponges known to Templeton was published in the ninth volume of Loudon's Magazine of Natural History, and a few

* A specimen once brought to me from Belfast market was stated to have been found among haddock sent from Glasgow, and most probably captured on the west coast of Scotland.

† Included in this number are two of Delle Chiaje's species from Sana island, on the Scottish coast, noticed by myself in the Annals of Nat. Hist. (vol. x. p. 20), and the seven last-named species of Mr. Hassall in the preceding catalogue, all of which require to be further studied with the view to ascertain whether they be really new or only synonymous with species previously described—indeed, the *Bereniceæ, Celleporæ* and *Lepraliæ* require a thorough revision.

‡ A highly interesting paper on the anatomy of the species, by Dr. Geo. J. Allman, has been published in the Proceedings of the Royal Irish Academy for 1843.

§ I have not seen the descriptions of these species of *Tubulipora.*

additional species were noticed by myself in the fifth volume (p. 254) of the Annals of Natural History. More recently, the native species obtained by Mr. Hassall, myself and others, and those procured by Wm. McCalla, collector to the Royal Dublin Society, were placed in Dr. Johnston's hands for description in his work on the British Sponges which appeared in 1842. They are fully treated of there, with the exception of one species, the *Grantia lacunosa* (which I obtained in Strangford lough in July 1838) being accidentally omitted. The names in the following list are those adopted in the work just mentioned.

AMORPHOZOA.

Class Amorphozoa, Blainv.—*Sponges.*

	Distribution.			
	North.	East.	West.	South.
Tethea lyncurium, *Lam.*	...	...	*	
Halichondria oculata, *Pall.* (sp.)	*	*		
,, cervicornis, *Pall.* (sp.)	*	*	...	*
,, Montagui, *Flem.*	...	*	*	
,, ventilabra, *Lin.* (sp.)	...	...	...	*
,, simulans, *Johnst.* (I.)	...	*	*	
,, cinerea, *Grant* (sp.)	...	*	*	
,, fucorum, *Esper* (sp.)	*			
,, panicea, *Pall.* (sp.)	*	*	*	
,, ægagropila, *Scouler, Johnst.* (I.)	...	...	*	
,, incrustans, *Esper* (sp.)	*	*		
,, saburrata, *Johnst.* (perhaps not distinct from last, Johnst. Sponges, p. 197.) (I.)	...	...	*	
,, areolata, *Johnst.*	*	*	*	
,, serrata, *Grant* (sp.)	...	*		
,,? celata, *Grant* (sp.)	*	...	*	
,, sanguinea, *Grant* (sp.)	...	*	*?	
,, hirsuta, *Flem.*	*			
,, suberea, *Mont.* (sp.)	*	*		
,, mammillaris, *Mull.* (sp.)	*			
,, carnosa, *Johnst.* (I.)	...	...	*	
Spongilla fluviatilis, *Pall.*	*	...	*	
Spongia pulchella, *Sow.*	*			
,, limbata, *Mont.*	*	*	*	
Grantia compressa, *Fabr.* (sp.)	*	*	*	*
,, lacunosa, *Bean, Johnst.*	*			
,, ciliata, *Fabr.* (sp.)	*	*	*	*
,, botryoides, *Ellis and Solan.* (sp.)	*	...	*	
,, fistulosa, *Johnst.* (I.)	*			
,, nivea, *Grant* (sp.)	...	...	*	
,, coriacea, *Mont.* (sp.)	...	*		
Dysidea fragilis, *Mont.* (sp.)	*	...	*	
,,? papillosa, *Johnst.*	*			

Class Lithophyta*.

Corallina officinalis, *Lin.*	*	*	*	*
Jania rubens, *Lamour., Lin.* (sp.)	*	*	*	*
Halimeda opuntia, *Lamour. Pall.* (sp.)	...	*		
Nullipora polymorpha, *Lin.* (sp.)	*	*	*	*
,, fasciculata, *Lam.* (sp.) (I.)	...	...	*	
,, agariciformis, *Pall.* (sp.) (I.)	...	...	*	

Of the fifty-one species of Sponge found in Great Britain, twenty-seven

* Now referred to the vegetable kingdom.

have been met with in Ireland, and 5 species—*Halichondria simulans, H. ægagropila, H. saburrata, H. carnosa, Grantia fistulosa*; all described as new—being indigenous to the latter island only, make our number thirty-two. The most common *Halichondriæ* thrown ashore on the north-east coast of Ireland are *H. fucorum* and *H. panicea*: on the Dublin coast the latter is in the highest perfection. *H. suberea* is not uncommonly dredged from deep water. *Spongilla fluviatilis* is found in several localities in the north, and both in swiftly-flowing and still waters.

Grantia compressa and *G. ciliata* are common on *Algæ* around the coast, as *G. botryoides* is in the north.

Of the twenty-four British Sponges unknown as Irish, the following species are recorded but from one district or one locality—*Geodia Zetlandica* and *Tethea cranium*, Shetland Isles—*Halichondria hispida, H. ramosa, H. plumosa, H. fruticosa, H. aurea, H. conus, H. rigida, H. perlevis*; *Spongia lævigata* and *Pachymatisma Johnstonia* from the south of England: of these ten species, seven rest on the authority of Montagu alone. *Halich. aculeata* and *H. virgultosa* are from Scarborough (Mr. Bean); *Halich. albescens* and *Halisarca Dujardinii* from Berwick and its vicinity (Dr. Johnston); *Halich. sevosa* from the Isle of Man (Mr. E. Forbes); *Spongilla lacustris* from the adjoining counties of Angus (or Forfar) and Fife; the remainder are *Halich. palmata* found in the Orkney and Shetland Islands, the east and south of England; *Halich. Columbæ*, Icolmkill and Brighton; *Halich. infundibulum*, northern islands of Scotland and Cumbrae; *Halich. coalita*, east and south Great Britain; *Halich. ficus*, Scarborough and Isle of Man; *Grantia pulverulenta*, Devon and Zetland.

Of the eight British species (or forms considered as such) of *Lithophyta*, four are known as Irish, and in the catalogue of the latter, two new species—*Nullipora fasciculata* and *N. agariciformis*—are included, thus making the number altogether six. *Corallina officinalis, Jania rubens,* and *Nullipora polymorpha*, are abundant round the coast. Of the four British species unknown as Irish, three—*Corallina elongata, C. squamata* and *Jania corniculata*—have been found only in the south of England; *Nullipora calcarea* there, and also on the west coast of Scotland: this last is considered by Dr. Johnston to be merely a state of *N. polymorpha*.

Conclusion.

The progress made in the portions of the Invertebrata of Ireland embraced in this Report has been indicated under the respective Classes. It is considerable in all, and exhibits, from the circumstance of our Fauna being about equally investigated with that of Great Britain, a fair comparison with the larger island*. Much still remains to be done in every department with reference to mere species, and to their distribution. The manner in which the various marine species are found associated together; the relative depths considered in connection with their mineralogical character; the many influences affecting the distribution of species, are subjects of inquiry, for the study of which the coast of Ireland offers a rich harvest†. Accurate observations on the habits and general economy of the species are always valuable. The

* More attention has been bestowed on the Mollusca Nudibranchia, Foraminifera and Annelida of Great Britain than on those of Ireland, where on the other hand the Mollusca Cephalopoda, Moll. Tunicata and Entozoa have (as to species) claimed more attention.

† The natural history of Ireland *exclusively* being alluded to, the all-important questions of structure and physiology are not mentioned, as they can be studied in every country which the species inhabits.

following is a brief summary of the departments in which the greatest additions to our knowledge as to species, &c. may be anticipated:—MOLLUSCA, Orders *Nudibranchiata* and *Tunicata* generally; *Cephalopoda*—as evinced by Mr. R. Ball's discoveries in one locality; *Pectinibranchiata*—minute species of the families *Turbinidæ* and *Buccinidæ*; *Lamellibranchiata*—in the species not to be met with on the beach, but only to be obtained by dredging. CRUSTACEA generally, excepting the order *Decapoda*. CIRRHIPEDA, with respect to the various forms assumed by each species. ANNELIDA generally, land, freshwater and marine: the testaceous species of the tribe *Serpulina*, though as to their mere number the best known, much require rigid analysis. FORAMINIFERA generally. ECHINODERMATA, the families *Holothuriadæ* and *Sipunculidæ*. ACALEPHA generally. ZOOPHYTA; in *Hydroida*, the soft species or those which do not form horny cases, as the genera Clava, Hydra, &c.; the *Helianthoida* generally; in *Ascidioida*, the genera Tubulipora and Lepralia, in reference to the extent of form assumed by the respective species. AMORPHOZOA or Sponges generally. ENTOZOA generally—tracing the forms assumed by the respective species from birth to their adult state, &c.

The chief collections of objects illustrative of the Zoology of Ireland are the following. In Dublin there are of public collections, the Ordnance Museum, Phœnix Park, good in various departments of Vertebrata and Invertebrata; the Royal College of Surgeons Museum, in which Mr. J. V. Thompson's collection of Crustacea is preserved; Trinity College, containing the late Mr. Tardy's fine collection of Insects, added to by Dr. Coulter; Natural History Society, Zoophytes, &c.; Royal Dublin Society, Vertebrata and Invertebrata: of private collections there are in the metropolis Mr. R. Ball's, very rich in the various branches of Vertebrata and Invertebrata; Miss M. Ball's, Insects chiefly, and Shells; Mr. Warren's, very fine in Shells and Birds; Dr. Farran's, also very fine in Shells, and good in Birds; Dr. Bellingham's, in Entozoa; Mr. Egan's, in Insects; Dr. George J. Allman's, in freshwater Zoophytes and Mollusca Nudibranchiata; Mr. O'Kelly's, in Shells *. In Belfast, the Museum of the Natural History Society contains a general collection of Vertebrata and Invertebrata, including the late Mr. Templeton's; Mr. Hyndman's collection is rich in Mollusca, Insects, &c.; Mr. Haliday's very rich in some orders of Insects; Dr. Drummond's in Entozoa and various Invertebrata; Mr. Patterson's in Insects; my own in various departments, Vertebrata and Invertebrata. In Cork, Dr. Harvey has a good collection of Vertebrata, as Mr. Clear has of Insects; Mr. Humphreys, of Shells; Mr. Samuel Wright, of Shells, &c.: Mr. Samuel Green of Youghal has a good collection of the eggs of native birds. In Limerick, Mr. Wm. Henry Harvey has a good collection of land, freshwater and marine Shells. In the county of Tipperary Mr. Robert Davis, Jun. of Clonmel, has a collection of Birds, and of the Eggs of Birds, the best in Ireland: the Rev. Thomas Knox of Toomavara has a good collection of Birds, as Mr. Edward Waller of Finnoe has of land and freshwater Shells: the late Mr. Hely had an extensive collection of the Insects of his district. Dr. Burkitt of Waterford has a large collection of Birds. Mr. John Vandeleur Stewart of Rockhill, Letterkenny, county of Donegal, has an extensive collection of Mammalia and Birds:—the Rev. Benj. J. Clarke, now of Tuam, of land and freshwater Mollusca:—Mrs. W. J. Hancock of Lurgan, of Shells, &c., from two localities on the western coast. The collection of Irish Shells formed by Capt. Brown now belongs to Lady Jardine, and that of Dr. Turton is in the possession of Mr. Jeffreys of Swansea.

* This collection having been formed previous to the publication of the catalogues of Dr. Turton and Capt. Brown, is frequently referred to by them. Mr. O'Kelly states that it was from him Dr. Turton first imbibed a taste for conchology: the genus *Kellia* was dedicated to him by this author.

Finally, it should be stated that the various Classes of the Vertebrate and Invertebrate animals of Ireland contained in this and the former Report are not treated of for the first time. They were all studied by JOHN TEMPLETON, and catalogues of the species they embrace, with the exception of Mollusca (omitted only because others had written on it), were published from his manuscript by his son (who is likewise most favourably known to zoologists) in the ninth volume of Loudon's Magazine of Natural History, and in the first volume of the same work conducted by Charlesworth: the former volume contains the Invertebrata; the latter, the Vertebrata.

The only portions of the Animal Kingdom as displayed in Ireland and not included in this Report (two parts), are Insecta (including *Myriapoda*, *Arachnoida*, &c.) and Infusoria. That the Insecta have not been altogether neglected, the following summary, kindly contributed by Mr. A. H. Haliday, will show. This distinguished entomologist remarks,—

"My catalogue, which has lain untouched for several seasons, contained of named and described species—

"*Coleoptera*, about 950. A good many of these from Mr. Tardy's MSS., and as his health for some years previous to his death had not allowed him to follow the progress of science, the additions from this source may require some revision.

"Some particulars as to Irish *Coleoptera* are given in Entomologist, Annals of Nat. Hist. vol. ii. Entom. Magazine, vol. iv.

"*Strepsiptera*, 2 species.

"*Orthoptera*, about 50. See Ent. Mag. vol. iii. iv.

"*Hemiptera*, under 150. The order very little examined yet.

"*Diptera*, about 1050. Annals Nat. Hist. ii. & iii. Zool. Journal, v. Ent. Mag. i. iii. iv.

"*Hymenoptera*, about 1100. Annals Nat. Hist. ii. Ent. Mag. 1—5. F. Walker, Monographia Chalciditum; A. H. Haliday, Hymenoptera Britannica.

"*Lepidoptera*, about 450, chiefly from Tardy's MSS. and collection, and requiring revision, as they had fallen into confusion. I had the liberty of availing myself of these from the late possessor, Dr. Coulter.

"*Thysanura*, about 22, collected by me. See Templeton in Trans. Ent. Society, vol. i. p. 89.

"*Neuroptera*, about 70.

"Total number of Irish Insects known, about 3850.

"Some additions in each I owe to W. Clear, Esq., and the collections, &c. of the late G. Hely and — Hafield, but I suppose nine-tenths of the whole (except *Lepidoptera*) were taken near Belfast; so that independent of the numbers unexamined and unnamed the selection affords no clue to the numbers of *Irish* Fauna. I have had opportunity however to judge that the south of Ireland does not afford the same increase of *forms* which we find in the like change of latitude in Great Britain.

"Stephens and Curtis both give, scattered throughout their principal works, information about the insects found in Ireland. There are also a *few* detached notices elsewhere which I cannot just now refer to."

To the above from Mr. Haliday it may be added, that some species found in the north of Ireland are incidentally noticed in Patterson's volume on the 'Insects mentioned in Shakspeare's Plays;' and that in Mr. Denny's work entitled 'Anoplura Britannica,' the Irish species are included. Mr. Robert Templeton, in addition to the *Thysanura* already mentioned, has published a list of the *Myriapoda** and *Arachnoida*†. The *Infusoria* have been little attended to: some native genera and species placed by some authors in the Animal Kingdom are described in Harvey's 'Manual of the British Algæ:' others of a similar nature have been brought before the Microscopical Society of Dublin by Capt. Portlock‡ and Mr. David Moore§. Dr. Geo. J. Allman‖ has likewise exhibited to that Society a few species of *Infusoria*, which it is unnecessary to name here.

In concluding this Report, it may be permitted me to state that no one can be more sensible than myself of its numerous imperfections. With the hope of diminishing their number by a more extended time, I was desirous of its postponement for another year, but it was urged that a Report on the Fauna of Ireland should be brought forward at an Irish meeting of the Association, and to this consideration I at length waived my desire for a longer period of preparation.

PROVISIONAL REPORTS AND NOTICES OF PROGRESS IN SPECIAL RESEARCHES ENTRUSTED TO COMMITTEES AND INDIVIDUALS.

Report on the Results of the Discussion of the Meteorological Observations made at Plymouth and Devonport at the request of the Association. By WM. SNOW HARRIS, *F.R.S.*

THE great mass of the results which these observations necessarily involved had precluded the possibility of completing a full report, such as would be requisite for the pages of the next volume of the Association: the necessary documents are, however, sufficiently complete to insure this report for the next meeting.

The first series of observations were those deduced from Mr. Whewell's anemometer, by which a result has been arrived at not dissimilar from that laid before the Meeting at Manchester, viz. the existence of a sort of trade-wind or current of air from south to north, in the place where the observations were made: this was exemplified by large typographical delineations of the aërial currents by lines proportional to the velocity and direction for given times laid down for the years 1841 and 1842.

Mr. Harris made some observations on the nature and capabilities of this instrument, and the results which might be expected from it in deducing the great annual movements of the atmosphere.

The result of the discussions of the observations with Osler's anemometer were next brought under consideration, which being regularly tabulated and discussed, indicated a mean hourly intensity of the wind in an order similar

* Loudon's Mag. Nat. Hist. ix.

† Id. and Zool. Journ. vol. v. p. 400. A singular parasite obtained on a Grey Seal (*Halichærus gryphus*) killed on the Dublin coast by Mr. R. Ball, has been investigated by Dr. Geo. J. Allman, who brings it under *Arachnoida* and constitutes a new genus—*Halarachne*—for its reception. He proposes to call the species *Halar. halichæri*: it will be described in the Annals of Natural History.

‡ Microscopic Journal, vol. ii. p. 6. § Id. vol. i. p. 159.

‖ An interesting paper on Fossil Infusoria from the county of Down was published by Dr. Drummond in Charlesworth's Magazine of Natural History, vol. iii. p. 353.

but inverse to that of the barometer, a major and minor wave occurring so as to produce two maxima and two minima of intensity. The full discussion of these observations had not yet been effected to a sufficient extent to exhibit all the various relations of the wind required.

The remaining observations on pressure and temperature were next considered, and graphic delineations of the mean hourly progress of the temperature, pressure, dew-point and intensity of the wind brought under one point of view in a general diagram.

Report of the Progress of the Inquiry into the Chemical History of Colouring Matters. By Professor KANE.

DR. KANE stated that as yet but little progress had been made in this inquiry. Some members of the Committee were however engaged in the investigation of the colouring matters of the lichens, and a few interesting results had been obtained.

Meteorological Observations at Inverness.

THESE observations were begun on November 1st, 1842, and are to be completed on November 1st, 1843. The observations with Osler's anemometer commence and terminate at the same dates.

It is to be hoped that the Association will authorize the continuation of the hourly observations, &c. for another year.

D. BREWSTER.

St. Leonard's College, St. Andrew's,
August 12, 1843.

Report of the Committee, consisting of Sir J. HERSCHEL, *Mr.* WHEWELL, *and Mr.* BAILY, *for revising the Nomenclature of the Stars.*

THE Committee report that they have reconsidered the subject since their last Report under a great variety of forms, and taken the opinions of many of the most eminent astronomers both at home and abroad on it. Understanding, however, that certain celestial charts of great merit have recently appeared in Germany, and that others are in progress of publication, which, if answerable to the expectations they have been led to form of them, may influence their decision both as to the names and boundaries of the constellations, they consider it desirable to defer their final decision till they shall have been enabled to consult these works, which they have accordingly ordered; and to meet the expense of which they request a continuance of the grant of 30*l*. remaining over applicable to the purposes of the Committee.

(Signed on the part of the Committee) J. F. W. HERSCHEL.

August 14, 1843.

On the Varieties of the Human Race.

SINCE the last meeting of the British Association, the queries drawn up by the Committee appointed to investigate the varieties of the human race have been extensively circulated; and although that Committee is not prepared to make any lengthened general report, it is due to the Zoological Section to state, that some interesting communications have been made by different travellers, who have found the queries themselves and the classification of their objects of essential service.

The Rev. Thomas Heath, who has just returned from the Navigators' Islands, has prepared a set of answers relating to the inhabitants of those islands, which it is probable that he will himself lay before the Section; and he contemplates at an early period giving in a more detailed form the results of his inquiries concerning language, traditions, mythology and customs. His investigations tend to show that the peopling of the Pacific Islands must have proceeded in a westerly direction, contrary to preconceived opinions deduced from the prevalence of winds and currents. It is a satisfactory confirmation of this traveller's observations, to find that the same conclusion has been drawn from very careful investigations which have been made during several years in the Sandwich Islands, and which were communicated to Dr. Hodgkin, a member of the Committee, in the course of the present year.

It must be gratifying to the members of the Association to learn that the subject of Ethnology, which on many accounts requires to be promptly and extensively cultivated, before numerous tribes now inhabiting the globe have ceased to exist, is not only studied with assiduity by our continental neighbours, but that an Ethnological Society has actually been formed in London since the last meeting of the British Association. The preliminary address, drawn up by a friend and countryman of the distinguished Humboldt, is well worthy the attention of the English ethnologist; since it points out not merely the numerous objects of scientific interest embraced by this subject, but also its peculiar claims to the patronage and support of the eminently maritime and commercial inhabitants of the British empire.

The expenses hitherto incurred in the distribution of questions and the receipt of replies have engrossed the trifling sum of *5l.* voted for this inquiry at the last meeting; and it is to be desired that the Association will re-appoint the Committee with such additions as it may think fit, and will place more adequate means at its disposal in order to effect a more extensive circulation, and to carry out other measures which the Committee has already had in contemplation; such as translations into foreign languages and the co-operation of foreign agents.

London, August 14, 1843.

Meteorological Hourly Observations at Unst.

These observations, which are not yet reduced, commenced on the 16th of May 1841, and terminated on the 16th of May 1842.

By some inexplicable accident the observations with the *External Thermometer* were omitted, or, rather, the thermometrical observations were made *within* the apartment.

The observations, which are very interesting and valuable in other respects, were under the superintendence of Dr. Edmonstone of Balta Sound.

From the circumstance already mentioned, it will be necessary to have another year's observations made at this station.

D. Brewster.

St. Leonard's College, St. Andrew's,
August 12, 1843.

On the Action of different Bodies on the Spectrum.

These observations have been carried on since the last meeting of the Association, and the properties of various rare substances have been examined.

Owing to the great want of sunshine in the locality of St. Andrew's this year, my observations on the direct solar spectrum have been comparatively few.

In a short communication to the Physical Section, I shall have occasion to mention a few of the results obtained during these investigations.

The pecuniary grant of the Association has not been exhausted; and it would be desirable to continue the balance as a new grant.

D. Brewster.

St. Leonard's College, St. Andrew's,
August 12, 1843.

Consumption of Fuel and prevention of Smoke.

In reference to the Report of the Committee, consisting of Mr. Houldsworth, Mr. Hodgkinson, Mr. Buck and myself, relative to the consumption of fuel and prevention of smoke, I have to state, that owing to a press of business, which required nearly the whole of my attention, I have not been able to devote much time to this inquiry. I believe my friend Mr. Hodgkinson has been similarly situated, in consequence of his inquiries into the laws which appear to regulate the elasticity of bodies. Mr. Houldsworth has, however, been pursuing his investigations on the intensity of heat in the flues and furnaces of boilers; and I entertain hopes that your Committee will be enabled to lay before the British Association, at their next meeting, a full and comprehensive report on this important subject.

Wm. Fairbairn.

London, August 16, 1843.

Internal Changes in the Constitution of Metals.

Although little has yet been done by your Committee appointed to conduct the "Experiments to ascertain whether or what changes take place in the internal constitution of metals when exposed to continual vibration and concussion, as in the case of axles of locomotive engines and other machinery," I have the satisfaction to report that a considerable quantity of information has been received and materials collected for these objects. In this stage of the inquiry it would be improper to anticipate results, which, from investigations now in progress, will probably be found different from those which appeared to receive the sanction of the Mechanical Section at the last meeting. Under all the circumstances your Committee respectfully pray for a renewal of the grant of 150*l*., no part of which has as yet been expended.

Wm. Fairbairn.

London, August 16, 1843,

Mr. Lucas (a member of the Committee) had tried several experiments with a view to the elucidation of this question, and he exhibited different specimens of bar-iron which show the conditions it assumed when manufactured under different circumstances.

Iron of the first quality, and which breaks with a fine fibrous texture, becomes by cold swagging changed into a crystalline texture, and consequently brittle. It is again restored by annealing to its first fibrous state. It has been found by experiments that mere concussion without any hammering suffices to produce the same crystalline structure.

Notice of Researches on Asphyxia.

68 Torrington Square, London, 8th August, 1843.

Sir,—On the part of Mr. Erichsen and myself, appointed at the last meeting of the British Association to conduct an experimental inquiry on the subject of Asphyxia, I beg to say that we have proceeded a certain length with our inquiry, but that, from various causes, it is not sufficiently advanced to enable us to give in our report at the ensuing meeting; we therefore crave the indulgence of the Association till next year. In the mean time I have to inform you, that our outlay up to this date is *5l. 3s. 8d.*, for which, as well as for any further expenditure, we can be reimbursed when we present our report.

W. Sharpey, M.D.

John Phillips, Esq.,
Assistant General Secretary of the British Association.

Report of Railroad Section Committee.

The Committee have to report the following account of the application of 200*l.* placed at their disposal at the meeting at Manchester 1842:—

		£	s.	d.
1842.				
Nov. 8.	Mr. Lowry for printing	10	0	0
	Charles Vignoles, Esq., for work done under his directions by Mr. Smallman	50	0	0
1843.				
April 27.	Balance for work done by Mr. Smallman under the direction of Mr. Vignoles	22	18	3
———	To Mr. Robinson Wright, for sections of the Hull and Selby and Manchester and Leeds railway (51 sheets)	50	0	0
———	To Mr. Jordan, three quarters of a year's salary, due March 25th, 1843	15	0	0
———	To Mr. Jordan, one quarter's salary, from March 25th to June 29th	5	0	0
	Balance in hand	47	1	9
		£200	0	0

The Committee are in treaty with Mr. Robinson Wright for a further series of sections on the Leeds and Selby line, and the Liverpool and Manchester line, in case a further grant of 200*l.* be placed at their disposal by the meeting at Cork.

The Committee recommend that an application be made to the Government on behalf of the Association, to solicit that the Illustrations of the Geological Structure of the country, hitherto conducted by a Committee of the Association, may hereafter be continued as a part of the Ordnance Geological Survey; and further recommend, that the Committee be authorized to present the drawings and engraved plates already executed to the Mining Record Office at the Museum of Economic Geology.

Northampton.
W. Buckland.
John Taylor.

The Report of Sir John Herschel on the Reduction of Meteorological Observations is illustrated by two Plates, exhibiting the barometric undulations observed by Mr. Birt in 1842. During November 1843 Mr. Birt again observed some very interesting waves, and he is desirous of obtaining, during next November, as many sections of waves as possible. For this purpose he will be most happy to furnish gentlemen (on application, by letter, to himself, Cambridge House Academy, Cambridge Road, Bethnal Green) with printed forms and instructions for making the observations, and all observations with which he may be favoured will be duly acknowledged and carefully discussed.

NOTICES

AND

ABSTRACTS OF COMMUNICATIONS

TO THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE,

AT THE

CORK MEETING, AUGUST 1843.

ADVERTISEMENT.

THE EDITORS of the following Notices consider themselves responsible only for the fidelity with which the views of the Authors are abstracted.

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[illegible]

NOTICES AND ABSTRACTS

OF

MISCELLANEOUS COMMUNICATIONS TO THE SECTIONS.

MATHEMATICS AND PHYSICS.

THE President, Professor MacCullagh, on taking the Chair, remarked on the connexion between pure mathematics and the physical sciences, and the reasons which had induced the Association to class them together as objects of the same Section. The geometer may pursue his speculations to an indefinite extent, without any reference to the external world; but he finds the best and most useful applications of them in the field of physical research,—in the study of those material laws, the knowledge of which is an essential element in the progress of the human race. Independently of their utility, the minds feels a natural—almost an irresistible—tendency to such applications. Even the great geometer of antiquity (Archimedes), who thought his science degraded the moment it became conversant about material objects, and was made subservient to merely useful purposes, was yet compelled, by the strong impulse of a natural curiosity, to deviate from the proud but narrow rule which he had prescribed to himself; and then the same splendid genius which had enabled him to find the proportions of the cylinder and sphere, and to approximate to some of the most refined methods of the modern geometry, led him to lay the foundation of *Rational Mechanics*—of that science which has since grown to such a wonderful extent, and has contributed so powerfully to the advancement of civilization. The laws of the visible universe are written in the diagrams of geometry and in the symbols of analysis; and this remarkable correspondence, established by the will of the Creator, between the mathematical conceptions of the human mind and the phænomena of the external world, was perceived by the philosophers of remote antiquity as clearly, and recognized as fully, as it is by those of the present day. It was the perception of this truth which caused Pythagoras to say that *numbers* are the principles of all things, and Plato to affirm that *geometry* is employed in the construction of the world. So great, indeed, was the predilection of Plato for geometry, that he required a previous acquaintance with it from all those who wished to become students of his philosophy; but while we agree with him as to the great importance of that science, more especially as an introduction to the study of physics, we shall not follow his example so far as to inscribe over the door of our Section-room, "Let no one who is not versed in geometry enter here;" for then we should exclude that large and important class of physical inquirers whose object is merely the discovery of new facts, and of elementary laws, which are the expressions of such facts. For in this way much may be done, and much has been done, by men slightly or not at all acquainted with mathematics, in which category will be found some of the most eminent names of modern science. But beyond such elementary laws it is impossible to proceed (as many an inventive mind has found when it was too late) without the help of mathematical science, which alone is competent to grasp the higher generalizations, and to discover those remoter laws which link together the more complicated phænomena, and enable us to predict them in all possible cases.

On a Theorem in the Calculus of Differences. *By* Sir WILLIAM ROWAN HAMILTON.

It is a curious and may be considered as an important problem in the Calculus of Differences, to assign an expression for the sum of the series

$$X = u_n\,(x+n)^n - u_{n-1}\cdot\frac{n}{1}\cdot(x+n-1)^n + u_{n-2}\cdot\frac{n\,(n-1)}{1\,.\,2}\cdot(x+n-2)^n - \&c.; \quad (1.)$$

which differs from the series for $\Delta^n x^n$ only by its introducing the coefficients u, determined by the conditions that

$$u_i = +1,\ 0,\ \text{or} -1, \text{ according as } x+i>0,\ =0,\ \text{or} <0. \quad \ldots\ldots (2.)$$

These conditions may be expressed by the formula

$$u_i = \frac{2}{\pi}\int_0^\infty \frac{dt}{t}\sin\,(xt+it)\,; \quad \ldots\ldots\ldots\ldots (3.)$$

and if we observe that

$$\frac{d}{dt}\sin\,(at+b) = a\sin\left(at+b+\frac{\pi}{2}\right),$$

$$\left(\frac{d}{dt}\right)^n\sin\,(at+b) = a^n\sin\left(at+b+\frac{n\pi}{2}\right),$$

we shall see that the series (1.) may be put under the form

$$X = \frac{2}{\pi}\int_0^\infty \frac{dt}{t}\left(\frac{d}{dt}\right)^n\Delta^n\sin\left(xt-\frac{n\pi}{2}\right); \quad \ldots\ldots (4.)$$

the characteristic Δ of difference being referred to x. But

$$\Delta\sin\,(2\alpha x+\beta) = 2\sin\alpha\sin\left(2\alpha x+\beta+\alpha+\frac{\pi}{2}\right),$$

$$\Delta^n\sin\,(2\alpha x+\beta) = (2\sin\alpha)^n\sin\left(2\alpha x+\beta+n\alpha+\frac{n\pi}{2}\right);$$

therefore, changing t, in (4.), to 2α, we find

$$X = \int_0^\infty \frac{d\alpha}{\alpha}\,\frac{d^n A}{d\alpha^n}, \quad \ldots\ldots\ldots\ldots\ldots\ldots (5.)$$

if we make, for abridgement,

$$A = \frac{2}{\pi}\sin\alpha^n\sin\,(2x\alpha+n\alpha). \quad \ldots\ldots\ldots\ldots\ldots (6.)$$

Again, the process of integration by parts gives

$$\int_0^\infty \frac{d\alpha}{\alpha^i}\,\frac{d^{n-i+1}A}{d\alpha^{n-i+1}} = i\int_0^\infty \frac{d\alpha}{\alpha^{i+1}}\,\frac{d^{n-i}A}{d\alpha^{n-i}},$$

provided that the function

$$\frac{1}{\alpha^i}\,\frac{d^{n-i}A}{d\alpha^{n-i}}$$

vanishes both when $\alpha = 0$ and when $\alpha = \infty$, and does not become infinite for any intermediate value of α, conditions which are satisfied here; we have, therefore, finally,

$$X = 1\,.\,2\,.\,3\ldots n\int_0^\infty d\alpha\,\frac{A}{\alpha^{n+1}}. \quad \ldots\ldots\ldots\ldots (7.)$$

Hence, if we make

$$P = \frac{X}{1\,.\,2\,.\,3\ldots n}, \text{ and } c = 2x+n, \quad \ldots\ldots\ldots\ldots (8.)$$

we shall have the expression

$$P = \frac{2}{\pi}\int_0^\infty d\alpha \left(\frac{\sin\alpha}{\alpha}\right)^n \frac{\sin c\alpha}{\alpha}, \quad \ldots\ldots\ldots\ldots \quad (9.)$$

as a transformation of the formula

$$\left.\begin{aligned} P = \frac{1}{1.2.3\ldots n.2^n}\Big\{(n+c)^n - \frac{n}{1}(n+c-2)^n + \frac{n(n-1)}{1.2}(n+c-4)^n - \&c. \\ -(n-c)^n + \frac{n}{1}(n-c-2)^n - \frac{n(n-1)}{1.2}(n-c-4)^n + \&c.\Big\}; \end{aligned}\right\} (10.)$$

each partial series being continued only as far as the quantities raised to the nth power are positive. Laplace has arrived at an equivalent transformation, but by a much less simple analysis.

On some investigations connected with the Calculus of Probabilities.
By Sir WILLIAM ROWAN HAMILTON.

Many questions in the mathematical theory of probabilities conduct to approximate expressions of the form

$$p = \frac{2}{\sqrt{\pi}}\int_0^t dt\, e^{-t^2}, \text{ that is, } p = \Theta(t),$$

Θ being the characteristic of a certain function which has been tabulated by Encke in a memoir on the method of least squares, translated in vol. ii. part 7. of Taylor's Scientific Memoirs, p being the probability sought, and t an auxiliary variable. Sir William Hamilton proposes to treat the equation $p = \Theta(t)$ as being, in all cases, rigorous, by suitably determining the auxiliary variable t, which variable he proposes to call the *argument of probability*, because it is the argument with which Encke's Table should be entered, in order to obtain, from that table, the numerical value of the probability p. He shows how to improve several of Laplace's approximate expressions for this argument t, and uses in many such questions a transformation of a certain double definite integral of the form

$$\frac{4 s^{\frac{1}{2}}}{\pi}\int_0^r dr \int_0^\infty du\, e^{-s u^2}\, U \cos(2 r s^{\frac{1}{2}} u V) = \Theta(r + \nu_1 r s^{-1} + \nu_2 r s^{-2} \ldots),$$

in which

$$U = 1 + \alpha_1 u^2 + \alpha_2 u^4 \ldots, \quad V = 1 + \beta_1 u^2 + \beta_2 u^4 \ldots,$$

while $\nu_1, \nu_2 \ldots$ depend on $\alpha_1 \ldots \beta_1 \ldots$ and r; thus $\nu_1 = \frac{1}{2}\alpha_1 - \beta_1 r^2$. The function Θ has the same form as before, so that if, for sufficiently large values of the number s (which represents, in many questions, the number of observations or events to be combined) a probability p can be expressed, exactly or nearly, by the foregoing double definite integral, then the *argument* t, of this probability p, will be expressed nearly by the formula

$$t = r(1 + \nu_1 s^{-1} + \nu_2 s^{-2}).$$

Numerical examples were given, in which the approximations thus obtained appeared to be very close. For instance, if a common die (supposed to be perfectly fair) be thrown six times, the probability that the sum of the six numbers which turn up in these six throws shall not be less than 18, nor more than 24, as represented rigorously by the integral

$$p = \frac{2}{\pi}\int_0^{\frac{\pi}{2}} dx \frac{\sin 7x}{\sin x}\left(\frac{\sin 6x}{6 \sin x}\right)^6, \text{ or by the fraction } \frac{27448}{46656};$$

while the approximate formula, deduced by the foregoing method, gives 27449 for the numerator of this fraction, or for the product $6^6 p$; the error of the resulting probability being therefore in this case only 6^{-6}. The advantage of the method is that what has here been called the *argument of probability* depends, in general, more simply than the probability itself on the conditions of a question; while the introduction of this new conception and nomenclature allows some of the most important known results respecting the mean results of many observations to be enunciated in a simple and elegant manner.

A paper was read on some Investigations connected with Equations of the Fifth Degree, by Sir W. Hamilton.

On the Method of Graphical Representation, as applied to Physical Results. By Professor LLOYD.

It is well known that if a series of ordinates be taken to denote the observed values of any physical quantities, the corresponding abscissæ denoting the respective values of the variable upon which it depends, the course of the first variable, at intermediate points, may be represented by drawing a curve through the extremities of the ordinates of observation, the exactness of the representation depending on the shortness of the intervals. The observed values of the ordinates, however, being subject to the errors of observation, it is manifest that their extremities are not necessarily points of the representative curve; and the object of the author was to inquire whether, and under what circumstances, *other* points could be substituted for those of immediate *observation,* the former being connected with the latter by known relations. Such a course is usually resorted to, when the intervals of observation are small, and the errors considerable, the curve being in such cases drawn (*not through*, but) *among* the points furnished by observation, allowing a weight in proportion to their number.

The validity of this process appears to depend on two principles, viz. first, that the positive and negative errors are equally probable; and second, the assumption that the function represented is not subject to abrupt changes. It is obvious, however, that its applicability in any particular case will depend upon the relation which subsists between the intervals of the successive ordinates and their probable errors; and it is important to know what that condition is. The points connected with those of observation by the simplest relations, are those obtained by bisecting the interval between each successive pair, or taking the arithmetical mean both of the ordinates and abscissæ. It is very easy to express in this case the relation sought. If $f(x)$ denote the value of the function represented, corresponding to the abscissa x, and if $x-h$ denote the preceding value of the latter, then it is obvious that the error committed by taking the arithmetical mean of $f(x)$ and $f(x-h)$, for the ordinate corresponding to the abscissa $x-\frac{1}{2}h$, will be represented by the series

$$f''(x)\frac{h^2}{1.2} - f'''(x)\frac{h^3}{1.2.3} + \&c.,$$

in which, in general, the first term may be made to surpass the sum of all the rest, by taking h sufficiently small. On the other hand, the error *saved* by the substitution of the arithmetical mean of the observed ordinates is

$$e\left(1-\frac{1}{\sqrt{2}}\right),$$

e denoting the probable error of a single observation; and the process in question will be advantageous when the former of these quantities is *less* than the latter. It thus appears that the condition of its applicability may be expressed by the following relation between h and e:

$$h^2 < \frac{\sqrt{2}(\sqrt{2}-1)e}{f''(x)}.$$

On the Theory of Total Reflexion, and of the Insensible Refraction which accompanies it. By Professor MACCULLAGH.

The phænomenon of total reflexion has for a long period excited the attention of mathematicians, who have endeavoured in vain to explain it; and it was regarded by Newton as an insuperable objection to the undulatory theory of light; for, according to him, the vibrations of the æther could not be suddenly stopped at the separating surface of the denser and rarer medium: as an elastic fluid communicates motion on all sides, the vibrations, on arriving at the surface of the rarer medium, would necessarily pass into it, and thus there would always be some refracted light; and total reflexion, on the hypothesis of undulations, would be impossible. It is curious, therefore, to observe that the phænomenon is now explained, and that for the first time, on this very hypothesis, and all its laws deduced with geometrical accuracy. The principles, however, on which the explanation is founded, are altogether new, though in strict accordance with the theory of waves, and the general laws of dynamics.

Before the condition of the totally reflected light can be determined, the motion which takes place in the rarer medium,—a motion not observable by the senses,—must be ascertained. This question is one which it was impossible to solve by the imperfect methods and defective principles hitherto employed, though Poisson had caught a glimpse of the way in which the solution was likely to be effected. In some investigations respecting the transmission of motion from one elastic medium into another, across their separating surface, he had found that in certain cases the disturbance in the second medium would be proportional to a negative exponential, which would diminish very rapidly as the distance from the separating surface increased; so that at a very small distance from that surface the disturbance would be quite insensible. This result enabled him, in a general way, to remove the objection which Newton had urged against the undulatory theory, because it furnished an instance in which the vibration did not sensibly spread beyond a certain surface; but, except so far as this, it did not give the least assistance in the solution of the question of total reflexion. It showed that a solution might possibly be found on the hypothesis of undulations; but this was all that it accomplished, for the formulæ of Poisson had not the remotest application to the case of luminiferous vibrations. The problem next occupied the attention of Fresnel, who succeeded completely in discovering the motions of the *reflected* light, by a most ingenious interpretation of the formulæ which he had found for the usual case of partial reflexion, and which give imaginary results when the reflexion is total. Perhaps the rare sagacity of Fresnel was never more conspicuous than in this remarkable instance, in which he applied his formulæ to a case which they did not originally include, and thus succeeded in divining, as it were, the laws that he was in search of. But these laws rested on no physical foundation; nor could they be made to do so without previously determining the laws of the insensible refraction with which they are necessarily connected. These latter laws, however, Fresnel had no means of divining, as he did the former. The meaning of the imaginary formulæ it was in this case impossible to conjecture; and even if it had been possible, still the two sets of laws could not have been connected, as the general relations which subsist between them were unknown; the relations which Fresnel had found sufficient in the case of partial reflexion being altogether powerless in this.

To find the laws of insensible refraction, it was necessary to know the general differential equations for the propagation of light in a transparent medium; and to deduce from these laws the laws of total reflexion, it was necessary to know the general equations which subsist at the confines of two transparent media. Both these sets of equations were given, for the first time, by Professor MacCullagh, the former having been originally published in the Philosophical Magazine for February 1836, the latter in the Proceedings of the Royal Irish Academy for December 1839. The equations had been first applied to the solution of the problem of reflexion and refraction, when the reflexion is partial and the refraction sensible, giving rise to one or two visible refracted rays, which is the simpler case, and was therefore the first solved, the solution having been given in the Proceedings of the Royal Irish Academy at the latter date. But it was some months later before Mr. MacCullagh perceived that these same differential equations included also the laws of total reflexion and of the accompanying insensible refraction, the only difference between this and the former case being the assumption of more general expressions for the integral of the equations of propagation. The expression for the displacement parallel to each axis of coordinates now contains a negative exponential of which the exponent is a linear function of the coordinates, this exponential being multiplied by a quantity which contains, in general, both the sine and cosine of the phase. By reason of this exponential, the vibrations in the rarer medium rapidly decrease in magnitude as the distance from the surface of separation increases, becoming insensible at a very small distance from that surface; and when the aforesaid expressions for the displacements are substituted in the equations of propagation, we get certain relations among the constants, which relations are in fact the laws of the insensible refraction. The laws of the totally reflected light are then easily deduced by means of the equations which subsist at the separating surface. It is to be observed that the reflexion is not *assumed* to be total, but is *proved* to be so, from the equations last mentioned; and the laws of this reflexion come out the very same (for ordinary media) as those discovered by Fresnel in the singular way before alluded to.

On account of the novel character of the laws of insensible refraction, Mr. MacCullagh entered into some details respecting them. The vibrations are in this case *elliptical*, every particle of the rarer medium describing an ellipse, which has the directions and the *proportion* of its axes everywhere the same; but the *magnitudes* of its axes rapidly diminish as the distance of the particle from the common surface of the media increases. It would, however, take up too much space to go into these laws, which will be published in the Transactions of the Royal Irish Academy.

The problem of total reflexion was considered by Fresnel only with reference to two ordinary media. The preceding method, however, is general, and solves the problem in its widest extent. The most complicated case is that in which the rarer medium is supposed to be a doubly refracting crystal, the crystal being covered with a fluid of greater refractive power than itself, so that total reflexion may take place at the common surface. We then have insensible refraction within the crystal, and it is found that this refraction is *double*, giving rise to two insensible waves, in each of which the vibrations are elliptical. The laws of this *insensible double refraction* are very general, and include, as a particular case, the laws of double refraction discovered by Fresnel.

Attempt to explain theoretically the Phænomena of Metallic Reflexion. By Professor Lloyd.

The physical hypothesis from which the author sets out is, that the elasticity of the æther (which is usually assumed to change abruptly at the confines of transparent media) varies *gradually* at the surface of a metal, so as to constitute, in fact, an infinite series of thin plates of infinitesimal thickness. In such a medium it is natural to suppose that there will be an infinite series of infinitesimal vibrations, reflected at every point in the course of the ray, the sum of which will constitute the resultant vibration. The magnitude (V) and phase (A) of this resultant vibration will be given by the formulæ

$$V \cos A = \int v \cos \alpha, \qquad V \sin A = \int v \sin \alpha;$$

where v denotes the magnitude of the infinitesimal vibration reflected at any point of the varying medium, and α its phase, and where the integrals are taken between limits corresponding to those of the varying medium. In these expressions the quantity v is readily deduced, in terms of the angle which the direction of the ray makes with the normal to the bounding surface, by setting out from Fresnel's expressions for the reflected vibrations in the case of a finite change of elasticity. The general value of α is also readily expressed in terms of the same angle, when the relation between this angle and the distance from the first surface of the varying medium is known. The latter relation cannot be certainly known *à priori*; but the author showed that there was reason to believe that it was expressed by the simple formula

$$\sin \theta = \sin \Theta \, e^{-qx};$$

Θ being the angle of incidence on the exterior surface of the medium, and q a constant. This being assumed, the two components of the resulting reflected vibration are expressed by single integrals, and the problem is therefore reduced to quadratures;

the expressions are different, according as the light is polarized in the plane of incidence, or in the perpendicular plane.

On pursuing the inquiry, however, the author found reason to conclude that there could be no sensible intensity in the reflected light without a *sudden* change in the elasticity of the medium; and he was accordingly driven to combine this hypothesis with that already referred to, the æther being supposed to vary continuously up to a certain plane, at which an abrupt change took place. On this principle he has obtained expressions for the magnitudes of the reflected vibrations corresponding with those of Fresnel, the two angles which enter the formulæ being connected with the original angle of incidence by the known law of the sines, by means of *two* constants. These expressions seem to explain, generally at least, the variations in the *intensity* of the light reflected from metals; but it remains to account for the *difference of phase* depending on the plane of polarization. The author hoped that he would be excused by the Section in laying before it an outline of a theory still incomplete. The problem, however, is one encompassed with difficulties; and any attempt, however imperfect, to obtain its solution may serve to direct further investigation.

Notice of an Experiment on the Ordinary Refraction of Iceland Spar. By Sir DAVID BREWSTER.

Professor MacCullagh of Trinity College, Dublin, in following out an hypothesis respecting light, has been led to a law of double refraction more general than that of Fresnel. One of the results of this law, though not a necessary consequence of Professor MacCullagh's theoretical views, was, that in all crystals with one axis of double refraction the ordinary ray was refracted according to a law different from that of Snellius. Instead of the two refractions being regulated by the sphere and spheroid of Huygens, they would be regulated by two ellipsoids touching each other at the extremities of a common diameter coinciding with the axis of the crystal—one ellipsoid differing slightly from a sphere, and the other slightly from a spheroid. Professor MacCullagh requested me to ascertain whether or not the ordinary refraction of Iceland spar varied at different inclinations to the axis, in the hope of finding such a difference as his theoretical views indicated. In place of doing this, by measuring the ordinary index with two separate prisms, I adopted the plan of cutting two prisms out of the same piece of Iceland spar—one having the refracted ray coincident with, and the other perpendicular to, the axis. These prisms were fastened by cement to a plate of glass, and their second surfaces ground and polished in that state, so that their refracting angles were necessarily equal. When this was done, I refracted the *yellow* homogeneous ray D of Fraunhofer, produced by a candle with a salted wick, and passing through a narrow aperture; and, looking through the refracting edges of both prisms with the same eye, I observed the most perfect coincidence between the two refracted images of the sharp line D. This placed it beyond a doubt that the ordinary ray had the same index of refraction in both prisms within the limits of the errors of observation. Professor MacCullagh's law, however, may still be true. The prisms used in this experiment were made with singular accuracy by Mr. George Sanderson, lapidary, Edinburgh.

Remark relative to the preceding Notice. By Professor MACCULLAGH.

The law referred to in the foregoing communication was merely conjectural. As Sir David Brewster has rightly remarked, it is not a necessary consequence of any principles that I have adopted. Its existence was barely permitted by those principles, so long as they were not restricted by the usual hypothesis of symmetry. Perhaps it may be proper to mention that the law was proposed chiefly with the view of accounting for certain very singular phænomena observed by Sir D. Brewster in the reflexion of light from Iceland spar. These phænomena are *unsymmetrical* with respect to the axis of the crystal, and this circumstance induced me to suppose that there might possibly be a corresponding want of symmetry in the law of refraction. The experiment which Sir D. Brewster was so kind as to make at my request, is, so far as it goes, against this supposition; and if further experiments should tend the same way (as most probably they will) it will follow that the unsymmetrical effects of reflexion do not arise from any cause which penetrates the interior of the crystal, but only from some peculiar structure of its surface. When the action of the crystal upon light is supposed to be symmetrical round its axis, the law in question reduces itself to that of Huygens; and in the case of a biaxal crystal, when the phænomena are supposed to be symmetrical with respect to three rectangular axes, the law coincides with that of Fresnel.

On the Action of Two Blue Oils upon Light. By Sir D. Brewster.

Having lately received, through the kindness of Dr. Gilbert, two remarkable oils of a deep blue colour, namely, the oil from the *Matricaria chamomilla,* and that from the *Achillea millefolia,* I was desirous of ascertaining the nature of their action upon the solar spectrum. Without entering into details respecting the general action of these oils upon the different coloured portions of the spectrum, I shall confine myself to a slight notice of their specific action, in which they differ from all the various bodies which I have yet examined.

Between the two lines A and B of Fraunhofer's map of the spectrum there are two groups of lines shown in that map. The *two* oils absorb the light in these portions more powerfully than the portions adjacent to them. No other fluid or solid body on which I have hitherto made experiments acts in a similar manner; but what is very remarkable, the earth's atmosphere exercises a similar action when the sun's light passes through its greatest thickness at sunrise or sunset.

Notice of a remarkable Photographic Process by which dormant Pictures are produced capable of development by the Breath or by keeping in a Moist Atmosphere. By Sir John Herschel.

If nitrate of silver, specific gravity 1·200, be added to ferro-tartaric acid, specific gravity 1·023, a precipitate falls, which is in great measure redissolved by a gentle heat, leaving a black sediment, which being cleared by subsidence, a liquid of a pale yellow colour is obtained, in which a further addition of the nitrate causes no turbidness. When the total quantity of the nitrated solution added amounts to about half the bulk of the ferro-tartaric acid, it is enough. The liquid so prepared does not alter by keeping in the dark.

Spread on paper and exposed *wet* to the sunshine (partly shaded) for a few seconds, no impression seems to have been made, but by degrees (although withdrawn from the action of the light) it developes itself spontaneously, and at length becomes very intense. But if the paper be thoroughly dried in the dark (in which state it is of a very pale greenish yellow colour) it possesses the singular property of receiving a dormant or invisible picture; to produce which (if it be, for instance, an engraving that is to be copied) from thirty seconds to a minute's exposure in the sunshine is requisite. It should not be continued too long, as not only is the ultimate effect less striking, but a picture begins to be *visibly* produced, which darkens spontaneously after it is withdrawn. But if the exposure be discontinued before this effect comes on, an invisible impression is the result, to develope which all that is necessary is to breathe upon it, when it immediately appears and very speedily acquires an extraordinary intensity and sharpness as if by magic. Instead of the breath it may be subjected to the regulated action of aqueous vapour, by laying it in a blotting-paper book of which some of the outer leaves on both sides have been damped, or by holding it over warm water.

Many preparations both of silver and gold possess a similar property, in an inferior degree, but none that I have yet met with to anything like the extent of that above described.

On a Change produced by Exposure to the Beams of the Sun in the Properties of an Elementary Substance. By Professor DRAPER *of New York. Communicated by* Dr. KANE.

Dr. Kane preliminarily described the general properties of the solar beam as acting on chemical substances, and pointed out the brilliant success with which the experiments of Daguerre and Niepce, of Herschel, Talbot and Hunt, had been crowned. He reminded the Section, that in analysing the solar beam, all parts of it were not found equally active in producing chemical effects; and that, in fact, the conclusion was now very generally admitted, that in the solar beam there are three distinct sets of rays:—those possessing heating properties, which are the calorific rays; those producing the sensation of light—the luminous rays; and those which effect chemical changes, which Dr. Draper proposes to call the Tithonic rays; for he, adopting the idea of peculiar matters of light and heat, considers that the chemical effects are produced by a peculiar material agent, which he terms Tithonicity. Dr. Kane then proceeded to read Professor Draper's paper itself, which commenced with announcing the principle that "chlorine gas, which has been exposed to the daylight or to sunshine, possesses qualities which are not possessed by chlorine made and kept in the dark. It acquires from that exposure the property of speedily uniting with hydrogen gas. This new property of the chlorine arises from its having absorbed tithonic rays, corresponding in refrangibility to the indigo." The property thus acquired is not transient, like heat, but permanent. A certain portion of the tithonic rays is absorbed, and becomes latent, before any visible effects ensue. Light, in producing a chemical effect, undergoes a change as well as the substance on which it acts: it becomes detithonized. The chemical force of the indigo ray is to that of the red as 66·6 to 1. The author remarked, that we are still imperfectly acquainted with the constitution of elementary bodies, inasmuch as we know, in general, only those properties which they possess after having been subjected to the influence of light.

On Elliptic Polarization in Light reflected from various substances. By the Rev. Professor POWELL.

In a communication to the Association at the Manchester Meeting, the author stated, amongst other results connected with this subject, that he had observed the phænomena of elliptic polarization in polarized light reflected from several mineral substances, in which it had not been (as far as he was aware) hitherto noticed. This inquiry bears upon the general question, to what substances is the property of converting plane into elliptic vibrations in the reflected light, confined? As far as observation has yet gone, it seems restricted in general to *metallic* substances, whether *pure* or compound; but to this there seem some exceptions, and it remains to be determined what *proportion* of metal in a compound is necessary to produce the result. As these questions will require an extensive range of observation for even a limited solution, the author is anxious to lay before the Association a list of all the substances he has examined, in the hope that others will be added to their number, whether by the independent experiments of those who may have access to such specimens, or by their favouring the author with the loan of such substances for examination.

The mode of examination is precisely that of which the author gave a sketch at the last meeting, and a full account of whish is published in the Philosophical Transactions for the present year. It is necessary that the specimens for examination should present a tolerably plane surface, capable of reflecting a sufficient quantity of light, of more than one-tenth of an inch square.

The following list contains the name of each substance examined, as labeled, and in some instances numbered, in the Buckland Collection at Oxford. Those marked with (B.) are among the substances examined by Sir D. Brewster. (Phil. Trans. 1830.) The proportion of metal given by analysis is added wherever the author has been able to find it given.

Name of Substance.	Ellipticity; at Incidence 40°.	70°.	Remarks and Analysis.
1. Mica from Hudson's Strait, opake metallic appearance	very small	very small	Apparent ellipticity in many specimens due to films.
2. Black mica	none	none	
3. Labrador spar, several varieties	none	none	
4. Sulphuret of lead (galæna), (B.)	small	considerable	Lead 85 in 100.—Thomson, Jameson.
5. Variegated do. No. 350	small	considerable	Iridescent, changes with tints.
6. Litharge	very small	large	
7. Sulphuret of copper	very small	considerable	
8. Peacock copper ore (two specimens)	very small, or none.	considerable	Copper 69 in 100.—Jameson.
9. Gray copper ore, No. 373	none	none	
10. Malachite, No. 238	none	none	
11. Brown hematite iron	none	very small	Oxide of iron 80 in 100.—Jameson.
12. Hexagonal iron glance, No. 367	none	very small	
13. Micaceous iron glance	none	none	Iron 70 or 80 in 100.—Jameson.
14. Variegated iron glance from Elba, No. 879	small or none	considerable	Oxide of iron 94 in 100.—Jameson.
15. Sulphate of iron	small or none	considerable	Oxide of iron 25 in 100.—Jameson.
16. Iron pyrites (cube), (B.)	very small	large	47 iron, 53 sulphur in 100.—Jameson.
17. Arseniferous antimony	small	large	Antimony with arsenic 61 in 100.—Jameson.
18. Ferruginous scheelin, 338	none	none	
19. Laminar titaneous iron	very small,	or none	
20. Hemitrope crystal of oxide of tin, No. 91	very small,	or none	
21. Green oxide of uranium	none	none	
22. Arsenical cobalt, (B.)	small	considerable	
23. Plumbago	small	considerable	5 iron, 95 carbon.—Thomson.

On the Changes which Bodies undergo in the Dark. By ROBERT HUNT.

At the last meeting of the British Association, great interest was excited on the announcement of a discovery by Moser, of Königsberg. This discovery was, that all bodies were capable, in the dark, of impressing their forms upon other bodies brought near them. Since that period three papers have been published in the Scientific Memoirs, which fully set forth the views entertained by Moser; and the subject has occupied the attention of Professor Draper of New York, of Mr. Prater and others in England, and also of Fizeau in France. Both Professors Moser and Draper attribute the phænomena, to the radiation, in darkness, of light which has been absorbed, and which remains latent in all bodies; while Fizeau seeks to explain them by the existence of films of organic matter, which are easily disturbed, and in this view he is followed by Sir David Brewster, by Professor Grove, and to a considerable extent by Mr. Prater. For the purpose of testing these hypotheses, Mr. Hunt made the following experiment. Three flat bottles, manufactured for Mr. Hunt's experiments on the influence of light on plants, were carefully prepared with three differently coloured fluids; an intense solution of carmine in ammonia, which admitted the permeation of the red rays only; a strong solution of the sulphate of chromium, through which but a portion of the most refrangible red and the orange and yellow rays only passed; and the ammonia sulphate of copper, which absorbed all but the most refrangible portion of the spectrum. Thus were obtained the means of isolating, with a tolerable degree of purity, the calorific, the luminous, and the chemical spectra. Having several designs cut out of white paper, these were placed on copper plates, and being covered with the above bottles of fluids, placed in the sunshine. After remaining exposed for different periods, at different times, from half an hour to three hours, they were brought from the light, and the plates placed in the mercurial vapour-box, and subjected to its influence. In no instance did any impression appear on the plates which were placed under the blue or yellow fluids, but in every case most decided impressions on those plates which were subjected to the influence of the red rays. Indeed, in some cases the impressions were beautifully visible without the use of mercurial vapour. It does therefore appear, when we take into consideration, besides the above facts, also the fact which has been admitted, that artificial heat at least accelerates this molecular change, that an amount of evidence has been obtained in favour of the hypothesis of calorific disturbance, superior to the supposed evidences in favour of the absorption and radiation of any other solar emanation. Mr. Hunt caused the prismatic spectrum, which was kept stationary by means of a heliostat, to fall upon unprepared copper-plates, and kept the plates under its influence for some time. On exposing these plates to mercurial vapour, the space over which the luminous rays fell was, to a certain extent, protected from the vapour, whilst the space which corresponded with the maximum calorific rays was thickly covered with it. Mr. Hunt varied his experiments with the spectrum, but a positive action was detected only in the thermic rays. From another series of experiments made with washed and unwashed plates, Mr. Hunt concluded that organic matter is not the cause of these images, but that the effect is due either to some disturbance of the latent caloric, which produces a molecular change, or to a thermo-electrical action, which it is difficult to understand. Had the effect been due, as M. Fizeau has stated, to slight layers of organic matter of a volatile nature, it appears natural to suppose that these mysterious images would have been found only on the very surfaces of the plates. Now this is far from being the case. These images are often found to be impressed to a great depth into the metal. Mr. Hunt in many cases removed several surfaces of copper, and yet had been able to revive the images. He possessed copper plates rendered useless by the impressions, which he has in vain endeavoured to remove.

On polishing the Specula of Telescopes. By Dr. Greene.

Dr. Greene apologized for presuming to speak of his humble efforts after the splendid achievements of the noble President of the Association in the same department, by stating that few possessed the means, the perseverance or the courage to attempt any thing even approaching the gigantic instruments already constructed, and now, on even a larger scale, in process of construction, by Lord Rosse, whilst many an amateur would be delighted to amuse himself at a small expense in that delightful path of science.

Dr. Greene then described the construction and action of his machine, which he illustrated on a small working model of only one foot in length, having then a mirror of one-inch aperture on its polisher. The doctor dwelt upon the greater convenience of using a machine turned by hand with a winch where the axes of the wheels are horizontal, than where they are vertical, as in Lord Rosse's, which is driven by a steam-engine. But the principle of the machine so nearly resembles that far more perfect machine of his lordship's, that by some few alterations it may be made identical with it in its mode of action. The general principle of the machine is this: a crank sets in motion a bar to which the mirror is attached, and which pushes it backwards and forwards over the polisher; while another crank, moving with a different velocity and through a different space, acting on the other bar in a direction at right angles to the former bar, continually deflects it from a rectilineal into a curved path over the surface of the polisher, which is constantly revolving slowly in one direction, whilst the mirror is made to revolve slowly in the opposite direction so as continually to change the portions of both that act upon each other. It is a remarkable fact, that since the first discovery of the reflecting telescope by Sir Isaac Newton, every optician and amateur has blindly followed in the path laid down by that illustrious philosopher, of polishing the mirror by rubbing it over the surface of a fixed polisher, the mirror being uppermost and the polisher under it. Lord Rosse was the first who ever tried the reverse of this process; he placed the mirror *below*, and moved the polisher *over*, its surface. To this simple change of position the doctor mainly attributed the uniform success of its illustrious inventor. By this change all the elements which enter into the one process are reversed in the other. In *grinding* the mirror on a metallic tool with emery, the perfection of that part of the process is to obtain a portion of a sphere, a figure known to every optician to be utterly unsuited to form a reflector, in consequence of the zones near the margin of the mirror being too much curved in proportion to those nearer the centre, and that a parabola is the required curve. Now a small portion of a circle can be changed to a parabola in two ways, either by increasing the curvature of the middle portion, or by diminishing the curvature of the extremes. In the former case the focus of a mirror so altered will be shortened, and in the latter case will be lengthened. It is found in polishing with the polisher undermost that the focus is shortened, while in Lord Rosse's method it is lengthened, which no doubt is the more simple and more certain mode of proceeding.

On the regular Variations of the Direction and Intensity of the Earth's Magnetic Force. By Professor LLOYD.

In this communication the author has given the principal results of the series of observations which have been made at the Dublin Magnetical Observatory, as far as they have been yet reduced. These observations were commenced in the beginning of the year 1839, and have been continued, almost without interruption, to the present time. Since the beginning of the year 1840, they were taken every two hours, day and night, in accordance with the general plan of observation laid down by the Royal Society. The elements directly observed are the *Declination* and the *two components* (horizontal and vertical) *of the Intensity*; and from the variations of the latter those of the *total Intensity* and *Inclination* are readily deduced. The means of observing the vertical component of the intensity having proved not altogether satisfactory, another instrument has since been contrived by the author, by which the changes of the inclination are given directly. Professor Lloyd would not occupy the time of the Meeting with any account of the instruments or methods of observation, which are now sufficiently known by all interested in the subject of terrestrial magnetism; but would proceed at once to the results obtained, so far as they related to the regular changes of the magnetic elements, commencing with the *diurnal changes*. These variations were projected in curves, which represented the course of the mean daily changes for the entire year, for the summer and winter half-years, and for each month separately.

Declination.—The mean daily curve of the changes of declination, for the entire year, exhibits a small easterly movement of the north end of the magnet during the morning hours, which reaches its maximum about 7 A.M. After that hour the north end moves rapidly westward, and reaches its extreme westerly position at $1^{h}\,10^{m}$ P.M. It then returns to the eastward, but less rapidly, the easterly deviation becoming a maximum about 10 P.M. The mean daily range is 9·3 minutes.

During the summer months the morning maximum at 7 A.M. is more marked; the evening maximum, on the contrary, disappears, there being a slow and regular movement of the north end to the eastward from 7 P.M. until 7 A.M. In winter, on the other hand, the evening maximum is well defined, and the morning maximum disappears, there being a slow and regular westerly movement until 9 A.M., after which the movement becomes more rapid in the same direction. The epoch of the extreme westerly position of the magnet is nearly the same throughout the year. The greatest daily range, in summer, is about 13·7 minutes; the least range, in winter, about 7·2 minutes.

Horizontal Intensity.—The mean daily course of the horizontal force, for the entire year, has two maxima and two minima. The first minimum occurs between 1 A.M. and

3 A.M., which is followed by a maximum about 5 A.M., or a little after. These fluctuations are small. A second and principal minimum takes place at $10^h\ 10^m$ A.M.; and a second or principal maximum about 6 P.M. The mean daily range is ·0024 of the whole intensity.

In the summer months the smaller maximum and minimum disappear, the intensity decreasing continually throughout the night, but slowly, until 5 or 6 A.M., after which the decrease becomes rapid. There are, consequently, but one maximum and one minimum in the mean daily curve, which correspond nearly in epoch with the principal maximum and minimum of the curve for the entire year. In the winter months, on the other hand, there are three maxima and three minima, the evening maximum appearing to break into two. The epoch of the morning maximum moves forward as the time approaches the winter solstice, appearing to depend upon the hour of sunrise, which it precedes by a short interval. The epoch of the principal minimum is nearly constant throughout the year. The daily range is greatest in the month of July, when it is about ·0045 of the whole intensity; it is least in the month of January, being then about ·0008 of the whole.

Total Intensity and Inclination.—The total intensity appears to vary very little throughout the day. It seems to be least about 9 A.M., and then to increase, attaining a double maximum in the afternoon. The total range however being very small, the variations of the two components of the intensity are dependent chiefly upon the changes of the inclination.

The inclination is greatest between 10^h and $10^h\ 30^m$ A.M., and least about 6 P.M., the epochs corresponding with those of the least and greatest values of the horizontal intensity. The daily range is about 2 minutes in the early part of the year, and increases to more than double of that amount in summer.

If we combine the changes of declination and inclination, the former being multiplied by the cosine of the absolute inclination, we obtain the whole movement of the north end of the magnet in free space, or the curve formed by the intersection of the magnetic axis with the sphere whose radius equals unity. The whole movement during the first six hours of the day is inconsiderable.

It appears, on a review of these facts, that the diurnal changes in the direction of the magnetic force are (as might be expected) connected with the diurnal movement of the sun, and its times of rising and setting. The changes of the intensity appear to be influenced in addition by some other cause, or by the same cause operating less directly.

Professor Lloyd concluded his paper by an account of the annual changes in the direction of the magnetic force at Dublin, as far as they have been hitherto determined.

On the Circumstances which affect the Energy of Artificial Magnets. *By* the Rev. W. Scoresby, *D.D., F.R.S.*

The object of this communication, Dr. Scoresby stated, was not to enter into the extensive bearings of the subject announced, which the time of the Section would not allow; but he might just state, in general terms, that the energy of permanent artificial magnets, of which alone he designed to speak, was affected by a considerable variety of circumstances, all acting by laws peculiar to themselves, and thus occasioning differences in the resultant energy whenever any of the circumstances might be changed. These circumstances comprised quality of steel, denomination (such as cast steel, shear steel, blister steel, &c.), temper or hardness, mass, and form. Hence, from the varying influence of these several circumstances, it was impossible to give a general answer to the inquiry, as to the best kind and temper of steel for permanent magnets. In large magnets, indeed, consisting of considerable combinations of bars or heavy masses, he, Dr. Scoresby, had sufficiently determined the fact, that best cast steel, made as hard as possible, was the most effective; but for small magnets or thin compass needles, shear steel, or cast steel tempered, became most effective. In a six-inch bar which he exhibited, of 600 to 700 grains' weight, hard cast steel was advantageously employed; but in thin plates, used singly or in pairs, such hardness required to be reduced. But by extensive investigation of the effects of these several conditions, if any particular case were stated, he could easily determine the requisite qualities. That the power of a magnet was essentially dependent on both *quality* and *hardness*, he, Dr. Scoresby, proceeded to show by experiment with four small bars of similar size, but of different qualities or tempers. One lifted only 600 grains, another about 1000, another the same, another 3200 grains. Tried by Dr. Scoresby's mode of testing described last year, he found the first to be bad in quality, the second inferior and too soft, the third good in quality but not hard enough, the last excellent in quality and hardness. In being in succession laid on the test bar, the first three lost all their power, whilst the last retained still the power of lifting a key of 3200 grains' weight.

Two anomalies in practical magnetism were then described. First, the experimentally determined fact, that proportional magnets of similar steel and temper were not energetic proportionally with their masses; in other words, that two magnets, one, for instance, being double in all its dimensions of the other, would not exhibit powers corresponding with their masses, or in proportion to the cubes of their lengths,—the proportions, instead of being as $1^3 : 2^3 = 8$, would perhaps be found to be as 1 to 5 or 6 only. Hence it would be inferred that magnets could not be advantageously enlarged to an indefinite extent: at the same time, from the experiments already made, he, Dr. Scoresby, would have no difficulty in constructing a magnet of a ton weight, and, by means of his peculiar test (which he had exhibited to the Section), of rendering every bar effective. The other anomaly to which he referred was that arising out of difference of form. In all his experiments on more than 1000 bars or plates, he had always found that extreme hardness was the most effective in large or considerable combinations of straight bar magnets. His surprise was therefore great on trying the same principle on two horse-shoe magnets of five and fifteen bars, to find that the same law did not prevail. The magnets, until reduced in temper, were of low power. To reduce them by a fixed and determinate rule, he, Dr. Scoresby, adopted a bath of oil boiling at about 600°. He tried the effect of various temperatures, from 300° to the boiling, and thence determined the ratio of improvement until he obtained the best. The magnets annealed ultimately at an uniform temperature of 505°, now exhibited very superior powers, lifting from seven to nine times their own weight.

Description of a Galvanometer. By J. P. Joule.

It is a well-established principle in electro-dynamics, that if a small magnetic needle be suspended in the centre of a coil or helix, and in the plane of its axis, the tangents of its deflections will be nearly, but not exactly, proportional to the quantity of current passing through the coil. It has therefore been found necessary to construct tables for turning the deflections of the needle into quantities of current. The necessity of forming these tables was first insisted upon by M. Becquerel; and in his treatise on Electricity he has pointed out the laborious experimental processes employed by himself and others in their construction. It is obvious that one table would suit all instruments possessing the same relative proportions. The instrument which Mr. Joule presented to the notice of the Association was designed as a *type* for the construction of galvanometers. It consisted of a needle, three inches long, suspended in the centre of a coil of six inches diameter. By a simple mechanical contrivance the coil could be removed from the instrument, and replaced by others adapted for the measurement of currents of different quantities and intensities; but in all cases their dimensions were to be exactly similar, and their diameter exactly twice the length of the needle. A most important part of the instrument was the needle, which was constructed on Dr. Scoresby's principle, and consisted of two straight and perfectly hard pieces of watch spring, placed at a distance from each other of about $\frac{3}{8}$ths of an inch, the agate cap being fixed between them. The importance of this form of needle consisted in the facility it presented of constructing different needles perfectly similar to one another with regard to the distribution of magnetism in them, which is essential to the accuracy of the same table applied to different instruments.

On a new Electrical Machine, and upon the Electricity of the Atmosphere. By JOHN NOTT.

This paper treated at great length of electrical currents and of the atmospheric electricity, by way of a preliminary to the consideration of terrestrial magnetism. The author insisted on the close analogy between the voltaic pile and a magnet. The difference between voltaic and frictional electricity he conceives to be, that the former is *in* the conducting wire, the latter *on* its surface, and therefore decomposed by whatever approaches it. Besides, the voltaic pile exhibits the two electricities and the current in which they unite; whereas the ordinary frictional machines develope and maintain but one electricity and no current. Among the novelties presented by the paper, may be mentioned the description of what the author calls the rheo-electric machine, in which both electricities are developed by friction. "It consists of a circular plate of glass and another of resin, both supported upon a horizontal axis, and set in motion by a winch handle; the rubber of the vitreous plate is connected by a metal rod with the rubber of the resinous one; and the conductor of the latter plate is also connected by a metal rod with that of the former, and thus a complete circuit is formed, as in the voltaic pile. The distribution of the electricity of this instrument is also analogous to that of the pile. For example, the electro-motive disturbance is produced by the plates; the rubber of the vitreous plate is rendered negative, that of the resinous one positive; and the conductors are also in opposite electric states, and their remote extremities are therefore analogous to the poles of the pile. When the conductors are connected by a conjunctive wire, it is natural to suppose that the accumulated electricities flow along its surface in opposite directions, for then an electric current is formed, which permanently deflects the magnetic needle, and the deflection is according to the direction of the current. The direction of motion of this current may be varied at pleasure; for instance, in order to fix our ideas, let us suppose the plates of this instrument and the axis of the conductors to be lying in parallel planes, perpendicular to what is called the magnetic meridian, the conjunctive wire connecting the conductors being bent at right angles, a portion of it will then be in the meridian, and the metal rod connecting the rubbers will be parallel to this portion. If now a magnetic needle be suspended above the conjunctive wire, and the resinous plate, which we will suppose to be placed north of the vitreous one, be connected with the earth, then a current of electricity passes from the resinous plate, and consequently flows along the conjunctive wire from north to south; the needle is then permanently deflected towards the west. If the needle be placed beneath the conjunctive wire, the deflection is towards the east. When the vitreous plate is connected with the earth the current flows from the vitreous plate, and the deflections are in the opposite directions." In the course of his experiments with this machine, the author found that all the parts of it which were made of brass became, by electrization, highly magnetic, and retained their magnetism for some time. The character of the magnetism thus produced will be understood by conceiving an orthographical projection of this instrument to be drawn upon a horizontal plane: it will be a parallelogram, of which the conjunctive wire will form one side, and the rod connecting the rubbers another: then all the brass parts of one half of this parallelogram, cut off by a diagonal line, will attract the north pole, and all of the other half the south pole. But if, immediately after electrization, either pole of the needle be forced into contact with any part of the brass conjunctive wire, it will develope an opposite magnetism to its own, and adhere to the wire as it would to a piece of iron. He also proved that water may be decomposed by the rheo-electric machine as with the galvanic current. The two electricities, as developed by this machine, appeared to him to be visibly different: the resinous electricity was subject to remarkable changes of colour, according to the state of the atmosphere and the nature of the exciting body. It also struck him that electricity is radiated in a peculiar manner from magnetized bodies. Combining this observation with a hypothesis respecting the electricity of the globe, viz. that the equatorial parts of the earth are in the resinous (in old language, negative) state of electricity, the poles vitreous (positive); while the atmosphere is, in its lower strata, vitreous, and in the upper resinous; the author proceeded to exhibit the phænomena of the aurora borealis by direct experiment. "I procured a globe of steel and magnetized it. It may not be unnecessary to state how this was effected. I suspended the globe upon an axis, and by a multiplying wheel and pulley set it in rapid rotation; while rotating I made the magnetizing bars traverse from the equator of the globe to the poles. I then tested it with a proof needle, and found it to be regularly and perfectly magnetized. The next object was to place this magnetic globe in similar electric circumstances to those which I conceived the earth to be in. Regarding that region of the atmosphere immediately over the torrid zone as the principal seat of atmospheric electricity, I conceived that if I surrounded the globe with a ring that would bear approximately the same proportion to the globe as this region of the atmosphere does to the earth, and electrized them oppositely, that the action of the electricity of the ring upon the air immediately enveloping the globe, would place the latter in nearly similar electric circumstances to those of the earth; if, then, the aurora were an electric phænomenon, that is, a discharge of free electricity, taking place from the pole of the earth, rendering the vortex, which I supposed to be immediately over the pole, luminous, from the great rarefaction of the air within it, and passing over our atmosphere to the upper stratum of the equatorial region, that as I could increase the electric intensity of my artificial terrella as I pleased, an analogous effect would be produced. This result followed with the greatest precision, as I shall now describe. I insulated the ring, and connected it with the resinous conductor of the rheo-electric machine. I also insulated the globe, and connected one of its poles with the vitreous conductor, and placed it so that its equator was surrounded by the ring. These bodies being electrized differently, and at a very short distance from one another, one would expect that a discharge would have taken place between them; instead of this, they at once reacted upon one another, so that the exterior of the ring being resinous, the interior became vitreous; the equator of the globe resinous, and both its poles highly vitreous; and a truly beautiful and luminous discharge took place from the unconnected pole. The state of the atmosphere has a remarkable effect upon the appearance of this discharge. One evening that the atmosphere was very dense, it had the appearance of a ring of light, the upper part of which was very brilliant, and the under part, towards the globe, was comparatively dark, just as we see at the bottom of ignited vapour; and indeed a vapour of some kind seemed to be ascending from the globe; above the ring, all round the axis, were foliated diverging flames, one behind the other. When the atmosphere is very dry it has merely the appearance of a beautiful electric brush. If the globe be moved towards any point of the interior of the ring, a discharge takes place in the line of shortest distance between them, and then there is a partial intermission of the auroral light. This experiment seems to point out the true cause of the aurora borealis." The situation of the points of greatest intensity (commonly called poles) in magnets, he conceived to be merely a result of figure. On a globular magnet the maximum intensity is, according to his experiments, situate about 75° from the equatorial zone. He maintained that the earth is a globular magnet, the maximum intensity of which is in lat. 75°, and that the magnetic poles of the earth have never yet been found. Terrestrial magnetism being considered as the effect of electric currents which move on the surface, will be affected by the irregularities of that surface, and hence the anomalies of the earth's magnetism. The author denied the conclusiveness of the arguments used to show that the earth is an oblate spheroid. He asserted that globular magnets, if freely suspended, would, by their mutual attraction, rotate and revolve round each other; and, finally, that the doctrine of gravitation must ultimately give way to that of universal magnetism.

On Determining the Index Error of a Circle by reflexion of the Wires of its Telescope. By the Rev. Dr. Robinson.

The observations made with an astronomical circle depend on an accurate determination of its index error, for which various methods have been adopted, all more or less limited in applicability or deficient in accuracy. The method proposed in the present notice appears so convenient and accurate, that Dr. R. thinks it may be useful to lay before the Section a few details respecting its precision. Illuminate the lines in the focus of the telescope behind, so as to leave the field dark; the rays forming an image of them, emerge parallel from the object-glass, and if reflected from a mercury trough back into the telescope, will form an image of the lines, visible along with them.

If the image of the declination line be made to coincide with it, the optic axis of the telescope is obviously vertical, and the reading of the circle gives the nadir. When Dr. R. found Kater's collimator uncertain, he made an illuminating eye-piece, and essayed this method with tolerable success in 1832, but as the power was but 25, he did not pursue it further than was necessary to obtain a value of his latitude. About three years since his attention was recalled to it by Mr. Henderson, who was using it with great advantage; and he made the necessary alteration in the observing eye-piece (power 250) to avoid the necessity of changing it when illuminating. He now finds this method much superior to the pole star observation in expedition, not inferior in certainty, and so easily practicable, that he in general determines the index correction at the close of each night's work. From the obvious fact that the angular movement of the image is *twice* that of the telescope, the precision is double that of a star, independent of the fluttering of the latter. Dr. R. would also call the attention of astronomers to the fact, that in determining the division corrections of a circle it must be remembered that they are occasionally variable with the position of the instrument, and with its temperature. It will, for instance, occasionally be found that the mean of six microscopes will differ from that of two, or of twelve from four by unequal quantities, when the readings of the index differ 180 degrees; and this throws a suspicion on the usual mode of examining divisions. The difference is far too great to be attributed to the error of observation, and appears to occur in every circle of which a detailed examination has been published. In the Armagh circle Dr. R. has found a few cases of the effect of temperature. The most prominent is that of the four divisions used for the nadir point, and it is remarkable that if this had not been attended to he would have found for α Lyræ and α Cygni parallaxes very nearly equal to those assigned them by Dr. Brinkley, Bishop of Cloyne. These remarks seem to furnish an argument in favour of the use of moderate-sized instruments, and the improvement of engine division.

On the Barometric Compensation of the Pendulum. By Dr. Robinson.

At the Manchester Meeting of the Association Professor Bessel made a communication on the improvement of the astronomical clock, which, with other valuable matter, contained a proposal to compensate for the changes of rate produced by the varying density of the atmosphere. This appears in the Report of the Sectional Proceedings, and also at much greater length in No. 465 of the 'Astronomische Nachrichten.' At the time Professor Stevelly remarked that I had not merely proposed but applied this compensation twelve years ago *; and I should not have reverted to it, but that I think my method possesses certain advantages over that proposed by the illustrious astronomer of Königsberg, which entitle it to the preference in practice. It was long believed to be demonstrated that the rate of a pendulum was influenced by the air's density only as far as it lessened the arc of vibration and diminished its gravity by buoyancy. The researches of Kater on the length of the second pendulum are all vitiated by this mistake, which was discovered by Bessel during a similar investigation, in which he found, by using balls of different specific gravities, that the received buoyancy correction is too small. As early as 1825, and without any knowledge of what Bessel was doing, I had ascertained the same fact by comparing the rates of my transit clock with the barometric indications; and Colonel Sabine gave the final proof of it by swinging the pendulum in a vacuum apparatus in the year 1829. The amount of it is far from inconsiderable; even with the mercurial pendulum of my transit clock, which weighs 21 pounds, and presents a very small surface, it is $0^s{\cdot}36$ for an inch change of the barometer. Now the remedy for this is obvious. If we attach a barometer to the pendulum, its fall transfers a cylinder of mercury from point near the axis of motion to a greater distance from it; the time of vibration may thus be made to increase by the same amount that it decreases in consequence of the diminished density of the air. By placing the clock *in vacuo*, as Bessel proposes (and as Sir James South has actually done for several years past), the effect of resistance can be determined exactly, and the *diameter* of the tube selected, which will nearly correct it. This is not mere speculation, for I have verified it by trial. The diameter

* Astronomical Memoirs, vol. v. Dependence of Clock's rate on Barometer.

which I selected for my tubes (0·1 inch) is not far from the truth. In the autumn of last year a fall of 1·6 inch produced *no appreciable change of arc*. The temperature, however, was then nearly stationary; but notwithstanding its changes during the interval from that time till my leaving Armagh, the arc has been between 1° 36′ and 1° 39′. Before the tubes were applied, the limits for the same period were 1° 42′ and 1° 51′. The changes in Bessel's own clock, though made by Kessel, a first-rate artist, were still greater, being from 1° 25′ to 1° 39′, an excess owing in part probably to the great severity of the German winter. From what I have seen of the vacuum apparatus used by Sabine or South, I cannot refrain from expressing a wish that the experiment were tried of mounting a transit clock permanently *in vacuo*: such a clock would have many advantages, besides its exemption from changes of barometric pressure.

Dr. Robinson communicated a Catalogue of Mean Places of 50 Telescopic Stars, within two degrees North Polar distance, observed at Markrea Castle, county of Sligo, by E. J. Cooper, Esq.

On Contour Maps. By Captain Larcom.

It is important that maps constructed by the government should exhibit the levels of the country in the most intelligible manner; showing heights not merely on the tops of hills, but round their sides, and through the valleys which traverse them. Such a system is offered by these contours. They are a series of horizontal lines, at a certain distance asunder, and at a certain height above a fixed datum. The datum most commonly used is the level of the sea, doubtless from the shore line being the limit of the land, and the point at which roads must cease, as well as from an impression that it is itself a level line; and therefore, as the first contour, the most appropriate and natural zero from which to reckon the others. The Section was aware that it has been a point much discussed, whether the high water, the low water, or the mean state of the tide, offers the most level line. This is a point which it would be out of place to discuss here, but it may be stated that, in order to determine it, as far as Ireland is concerned, a series of lines has been very accurately levelled across the island in various directions, and permanent marks are left in all the towns, and on numerous public buildings; and at the end of each of these lines on the coast, tidal observations have been made every five minutes during two complete lunations. These observations, and the connecting lines of level, are now in process of reduction —the degree of accuracy attained is such that a discrepancy of ·2 of an inch is immediately apparent—and from them we may expect many points of interest. The steeper the natural slope of the ground is, the closer together the contours of course will be, and the more oblique the road: where, on the contrary, the ground slopes very gently, the contours are further asunder, and the road may be proportionally more direct. By examining the maps of the Irish Survey, on which contours have been drawn, it will be seen that they tell sad tales of the existing roads, every one of which ascends and descends frequently, instead of keeping on a gradual slope for its whole length. In order to exhibit these lines, it is proposed, instead of adding them to the original copper-plate, which has a peculiar value as an official record of boundaries, to make a copy of the plate by the electrotype, for the purpose of receiving them. Contour maps were thought of early in the progress of the survey, but means were wanting for their execution; at present, however, the outline survey being complete, and the general map, or map of the surface, being in progress, a convenient opportunity is afforded, which it is hoped will not be lost.

Account of the extraordinary Flux and Reflux of the Sea, July 5, 1843, *at Arbroath. By* Alex. Brown. *Communicated by* Sir David Brewster.

An extraordinary flux and reflux of the sea was observed at different places along the east coast of Scotland on the afternoon and evening of Wednesday the 5th of

July, 1843. The following is a short account of the phænomenon as it was observed in Arbroath Harbour.

The neap tides at Arbroath Harbour rise to a height generally varying from eight to nine feet. On the 5th of July the moon was twenty-four hours past her first quadrature, and at two o'clock on the afternoon of that day she was in perigee; the neap tide on that afternoon would therefore be about its maximum, that is, about nine feet; but at the time of high water at eight o'clock on the evening of the above-mentioned day, the tide was at times observed to rise to a height varying from nine and a half to eleven feet; the flux and reflux was first observed about five o'clock in the afternoon, and continued up till about the time of high water at eight o'clock. The vertical depth of each wave was from one and a half to two feet, and the time of flux or reflux ten minutes, with an intervening space of from five to ten minutes between the rising and falling of each wave. I have been unable to ascertain whether the phænomenon commenced or terminated with a rising or falling wave, or to what horizontal distance each wave retired or flowed up. The masters of vessels who were a little distance out at sea state that they observed a stronger current than usual running at the same time that the extraordinary flux and reflux was observed in the harbour. The sea at the time (excepting the rising and falling) was perfectly smooth, there being then very little wind. Near the time of high water at the two succeeding tides the same phænomenon was observed, but not to the same extent as on Wednesday evening. At seven o'clock on the same evening a violent thunder-storm came on and lasted for the space of two hours, during which the fall of rain amounted to one inch and a half, the barometer at 10 P.M. standing at 29·48 inches, and at 10 A.M. next morning at 29·42 inches. The Harbour-master at this port, who has observed a similar phænomenon before, gives it as his opinion that it is the effect of a storm in the Atlantic ocean, the wind blowing from north-west.

Remarks on Abnormal Tides. By Mr. THOMAS *of Falmouth.*

These remarks had been made in consequence of seeing, in a Report of the Association, the cause which had been assigned by Mr. Russell for the double tides observed in the Frith of Forth, viz. the interference of the northern and southern tidal waves. It appeared to the writer that this cannot be the rationale of the phænomena, since they occur in places where no such cause exists, as in Falmouth; besides, he thinks that if this be the cause, it should be observed at Leith, where the meeting waves differ two hours in time, and not merely high up in the Frith. He thinks a difference in velocity at different parts of its rise, and the influence of strong winds, sufficient to account for the phænomena.

On the Nature and Causes of the Diurnal Oscillations of the Barometer. By G. HUTCHISON.

In the first part of this paper, the author, after stating the leading features of the phænomenon, argued that the three explanatory suggestions previously advanced relative to its cause, viz. diurnal variations of temperature, diurnal variations in the amount of moisture in the atmosphere, and diurnal variations in the force of the wind, whatever influence they might separately and conjointly have in modifying the extent of the atmospheric tides and the periods when their maxima and minima are attained, were totally inadequate to account for the broad features of the phænomenon, as exhibited in intertropical climates. The author then ascribed the phænomenon of diurnal atmospheric tides to the ever-varying degrees in which the rotatory and orbital movements act, either in union with, or in opposition to each other in different latitudes during the course of twenty-four hours, and the different seasons of the year. During night, when the orbital and rotatory movements cooperate more or less in direction, the excess of acquired velocity through space in the orbital direction above the mean of 68,000 miles an hour, must communicate some degree of lateral pressure to the atmosphere in the direction of rotation. On the contrary, during day, when the orbital and rotatory movements act more or less in opposition to each other, the atmosphere must be subject to an equal amount of lateral pressure in the opposite direction of rotation. But when the atmosphere was moving in the orbital direction, with its mean velocity of 68,000 miles an hour, which occurred only at six o'clock A.M. and P.M., no lateral pressure could thence result, for the rotatory and orbital movements of the atmosphere, through space, were then equal to, and therefore nullified, or neutralized, its acquired velocity. The theory advanced is also supported by the results obtained from laborious reductions of long-continued observations made in different places, in temperate latitudes, by different philosophers. From these it appears, that even in temperate latitudes the atmospheric tides attain two maxima and two minima annually, the former occurring during spring and autumn, the latter during summer and winter. This, on the supposition of the theory being true, is exactly what ought to take place. In consequence of the rotatory and orbital movements coinciding more directly during night, and being more directly opposed to each other during day at the equinoxes than at other seasons, it is in accordance with the theory under consideration, that the atmospheric tides should attain their maxima about these periods of the year; and upon the same principle, in consequence of the greater divergence of these forces from exact cooperation with or opposition to each other at the summer and winter solstices than at other seasons, it is also in accordance with our theory, that the atmospheric tides should attain their maxima about these periods of the year.

Meteorological Register for 1842–43, *from Diurnal Observations taken at Beddgelert in the county of Carnarvon. By* John Prichard.

Month.	Barometer.		Thermometer.		Wind.								Pluviometer.	Diurnal state of the Weather.			
	Maximum during the month.	Minimum.	Maximum.	Minimum.	North.	North-east.	North-west.	West.	South.	South-east.	South-west.	East.	Fall of rain in inches and parts.	Fair.	Rain.	Snow.	Changeable.
1842.																	
June	30·07	29·22	69	52	...	...	6	2	5	2	14	1	5·12	20	3	...	7
July	30·15	29·10	64	52	4	1	11	4	2	...	9	...	8·27	17	5	...	9
August ..	30·17	29·41	68	50	1	2	3	2	...	4	19	...	4·12	19	1	...	11
Sept. ...	30·03	29·00	62	48	...	...	12	1	...	...	10	7	7·54	18	4	...	8
October..	30·27	28·32	54	32	9	4	9	...	...	...	4	5	4·53	18	6	1	6
Nov.	30·16	28·06	50	36	...	1	3	3	1	1	11	10	11·96	11	12	...	7
Dec.	30·20	28·85	56	36	...	...	6	4	1	1	18	1	7·65	8	12	...	11
1843.																	
January .	30·20	28·30	52	30	6	...	7	4	...	...	14	...	5·35	8	10	3	10
February	29·80	28·55	46	20	6	2	3	1	1	2	2	11	1·65	17	1	1	9
March...	30·08	28·80	56	27	1	...	2	1	3	1	14	9	3·42	18	3	...	10
April ...	29·75	28·80	52	32	2	4	5	1	...	...	17	1	8·06	9	10	3	8
May	29·93	29·10	53	42	2	...	4	1	2	6	11	5	3·69	13	4	...	14
					31	14	71	24	15	17	143	50	71·36	176	71	8	110

Beddgelert is situate on the south-west side of the Snowdonian range of mountains in the county of Carnarvon, North Wales.

On the Correction to be applied for Moisture to the Barometric Formula. By J. Apjohn, *M.D.*

If the atmosphere were of one uniform temperature throughout, destitute of moisture, and the intensity of gravity were also constant, it is well known that the difference of the altitudes of any two points in the atmosphere would be represented correctly by the formula $D = m \times \log \frac{p}{p'}$, m being a constant quantity, and p and p' being the respective pressures at the upper and lower stations, as measured by the barometer, or in any other way. The conditions, however, which lead to this simple expression, are in nature never fulfilled; for it will seldom happen that the temperature of either station is 32°, and the atmosphere always includes a greater or less amount of aqueous vapour. A correction for temperature has been long applied, by augmenting or diminishing the approximate height, or $m \times \log \frac{p}{p'}$, by the amount that a column of air of this length would expand or contract, if its temperature were changed from 32° to $\frac{t+\theta}{2}$, t being the temperature of the lower, and θ that of the upper extremity of the aërial column, by which the expression becomes

$$D = m \times \log \frac{p}{p'} (1 \pm \frac{\left(\frac{t+\theta}{2} - 32\right)}{493}.$$

Such is, I believe, a correct account of the present form of the barometric formula; at least, when we neglect the correction for variation of gravity, which is, however, so minute as to be in general safely negligible. The presence of moisture in the air must obviously exercise some disturbing effect upon this formula; but though this has been generally admitted by those who have turned their attention to the subject, I am not aware that any attempt at estimating its exact amount has been as yet made; and as the correction for moisture is frequently of considerable magnitude, and may, in my opinion, be applied with as much accuracy as that for temperature, I have taken the liberty of occupying for a few moments the time of the Section with an explanation of the method which it has occurred to me to devise, and with which, from some trials I have made of it, I feel every reason to be satisfied. Let p be the pressure, and t the temperature of the air at the lower station, t'' the dew-point of the air, and f'' the force of the included vapour; and let p', θ, θ'' and F'' represent the corresponding quantities at the upper station. This being understood, a little consideration will suffice to show that the presence of the aqueous vapour produces upon the formula a twofold deranging effect. It augments the values of p and p' beyond what they would be in dry air; and it produces an alteration in the length of the column of air between the two stations, additional to that which results from the difference between its mean temperature and 32°, or the freezing point. The first of these is obviated, or, in other words, the correction for it is made, by substituting for p and p' in the approximate formula, $p-f''$ and $p'-F''$, by which it becomes

$$D = m \times \log \frac{p-f''}{p'-F''}.$$

Having thus eliminated the effects of the tension of aqueous vapour upon the pressures, we have next to estimate the conjoint influence of it and temperature in elongating the pillar of air between the two stations. The theory of mixed gases and vapours enables us to do this, provided we can assign proper mean values to the temperature, the pressure, and the force of vapour of the aërial column in question. The mean temperature is usually taken as $\frac{t+\theta}{2}$; and this must be very nearly its true value. For the same reason the mean force of the vapour may be set down as $\frac{f''+F''}{2}$; and let us assume the mean value belonging to the pressure as $\sqrt{(p-f'') \times (p'-p''}$. Now volume v, of dry air at 32°, under a pressure p, if raised to a temperature t'', becomes $v \times \frac{461+t''}{493}$; and if saturated with vapour at this temperature, the tension of such vapour being f'', will become $v \times \frac{461+t''}{493} \times \frac{p}{p-f''}$. This is the volume of the air when raised to t'', and saturated at this temperature with vapour. And if this volume of air have its temperature further raised, we shall say to t, then its bulk will be represented by the expression

$$v \times \frac{461+t''}{493} \times \frac{p}{p-f''} \times \frac{461+t}{461+t''} = v \times \frac{461+t}{493} \times \frac{p}{p-f''}.$$

Substituting then in this expression, instead of v, the value of the length of the column of air between the stations supposed dry, and at 32°, viz. $m \times \log \frac{p - f''}{p' - F''}$, and for p, t, and f'', their proper mean values as already explained, the barometric formula finally becomes

$$D = m \times \log \frac{p - f''}{p' - F''} \times \frac{461 + \frac{1}{2}(t + \theta)}{493} \times \frac{\sqrt{(p - f'') \times (p' - F'')}}{\sqrt{(p - f'') \times (p' - F'')} - \frac{1}{2}(f'' + F'')}.$$

I may add here, that the correction for moisture is far from being insignificant in its amount, as may be seen by the following example. Let us suppose that, when the approximate height corrected for temperature amounts to 2700 feet (a height reached by several of our Irish mountains), the mean value of the pressure to be used in the final factor of the formula is 27·3, and of the force of vapour ·3 of an inch, then the elongation of the aërial column resulting from moisture is $\frac{3}{270} = \frac{1}{90}$th of $2700 = 30$ feet. It will, of course, have been observed, that the correction for aqueous vapour differs from that for temperature in the circumstance of being always positive; and this coincides perfectly with the observation I have had frequent occasion of making, viz. that heights calculated by the formula in general use, are all appreciably less than the truth. I may, in conclusion, observe, that in assuming—with the view of calculating the expansion produced by moisture—that the pressure to be employed is the geometric mean of the corrected pressures got by observation at the two stations, I am quite aware that I am assigning to it but an approximate value. An exact expression for the pressure to be employed admits of being investigated; but its introduction into the formula, while it would give this latter complexity of form, and thus render it less suited for practical use, would conduct to results not appreciably different from those given by the more simple method just explained.

Observations with the Thermometer made at Aden in Arabia. *By* Corporal William Moyes.

The following summary of these observations was drawn up by the Marquis of Northampton:—

Greatest height in the shade occurred at 12 and 2 on the 1st and 2nd, 100°.

Greatest height in the sun on the 1st, 120°.

Least in the shade at 2 A.M., 4th, 82°.

Least in the sun at 8 in the evening, 13th, 14th, 15th, 94°.

Greatest rise in an hour in the sun at 10 in the morning, 15th, from 94° to 109°.

Greatest morning variation in the sun, 6th and 7th, from 96° to 108°; and on the 27th and 28th, from 108° to 98°.

Greatest evening variation in the sun on the 7th and 8th, from 108° to 100°; and on the 26th and 27th, from 104° to 96°.

Greatest morning variation in the shade, 11th and 12th, from 85° to 88°; and on the 13th and 14th, from 86° to 89°.

Greatest variation in the shade at noon on the 6th and 7th, 98° to 90°.

Greatest variation in the shade in the evening, 24th and 25th, 89° to 85°; 26th and 27th, 85° to 89°; 28th and 29th, 90° to 86°.

Greatest variation at noon in the sun, 6th and 7th, 106° to 121°.

On the quantity of Rain which falls in the south-west of Ireland, and in Suffolk, with the wind at the several points of the Compass. *By* the Rev. Thomas Knox and the Rev. Henry Knox. *Communicated by* Professor Lloyd.

The instrument employed in these observations was contrived by the Rev. Thomas Knox, for the purpose of registering the amount of rain which falls at a given place, with the wind in different points of the compass. A description of its construction has been given in the Proceedings of the Royal Irish Academy. The present communication contains the results of a series of observations made with two of these instruments, one of which was erected at Toomavara, in the county of Tipperary, and the other at Monk's Eleigh, in Suffolk. The observations embrace a period of one year, and are illustrated with diagrams, which represent the results obtained at the two stations, for the whole year, for each quarter of the year, and for the individual months. The following Table gives the results for the entire year, expressed in inches.

	S.	S.W.	W.	N.W.	N.	N.E.	E.	S.E.	Total.
Toomavara ...	4·249	12·696	8·150	2·640	3·115	3·078	3·101	3·523	40·552
Monk's Eleigh	2·674	2·756	4·371	2·392	2·776	2·027	3·092	1·708	21·796

It appears from this Table, that while the total amount of rain which falls in Tipperary is nearly double of that which falls in Suffolk, there is likewise a wide difference between the two stations as to the quantity which falls with different winds. In fact, nearly one-third of the whole amount of rain falls at the Irish station during the prevalence of the south-westerly winds, while at the English station there is a much nearer approach to equality in the amount of rain borne by different winds. This prevalence of rain with the south-westerly wind is distinctly marked in every season of the year at the Irish station; while at the English one each season is characterized by an excess of rain from a different point of the compass, producing a near approach to uniformity in the results of the entire year. It is to be observed, that these results are integral effects. A comparison of them with the times of continuance of the respective winds, gives the *raininess* (if it may be so called) of the several winds.

Experiments to prove that all Bodies are in some degree Inelastic, and a proposed Law for estimating the Deficiency. By E. HODGKINSON, *F.R.S.*

Mr. Hodgkinson said it was a principle generally acknowledged in the present day, and employed by those who have written on the subject of elasticity, that when bodies are acted upon by forces tending to elongate or compress them in a small degree, the changes produced are in proportion to those forces, and that equal extension and compression are produced by equal forces. That this principle is true, so long as the change produced in bodies is very small, is not doubted; and as regards *extensions*, it is the basis of the early investigations of James Bernouilli on the elastic curve; of Hooke, who was its author ('Theory of Springs'), Mariotte, Leibnitz ('De Resistentia Solidorum,' 1684). It was adopted in the profound inquiries of Euler on the strength of columns, which were corroborated by Lagrange (Berlin Memoirs); and with respect both to *extensions* and *compressions*, it forms the basis of the calculations on the strength and elasticity of bodies in the principal theoretical and practical works on mechanics of the present day, as the 'Mécanique' of Poisson, and the works of Whewell, &c., the practical treatises of Navier, Poncelet, Tredgold, Barlow, Moseley, &c. He hoped, however, to convince the Section that this principle does not operate *alone* in the resistance of bodies subjected to tension, or to compression, or to both. He hoped, too, to show the law which the element, not considered by writers, nor generally known to exist, is subject to. This element is a defect of elasticity, or set, to which all bodies made to undergo a change of form, however small, seem to be liable. The defect here mentioned was known to exist only when the body had been strained with a considerable force, or such as to be equal to one-third or upwards of the breaking weight. But the experiments which he should adduce would show that the defect commences with the smallest changes of form, and is increased according to the square of the extension, or compression, or of the weight. Thus, if e represent the extension or compression which the strained body had undergone, and $a\,e$ the force which would have produced that extension or compression if the body had been perfectly elastic, the real force necessary to produce this change, e, will be less than the former by a quantity, $b\,e^2$, representing the defect of elasticity. Hence the force required to produce a change, e, is

$ae - be^2$, where a and b are constant quantities. He had found this law to obtain when the change produced in the body arose from extension or compression alone; but when the change arose both from extension and compression, as in the flexure of a rectangular body, the force of a fibre was less than that due to perfect elasticity, as $ax - bx^2$ to ax; or it was equal to $ax - bx^2$, where x was the weight applied, and a, b constant quantities as before.

In proof of these statements, Mr. Hodgkinson mentioned, that having remarked, in his experiments made for the British Association on the subject of hot and cold-blast iron, that the elasticity of bars, broken transversely, was injured much earlier than was generally assumed, he paid particular attention to this circumstance in his future experiments, and had bars so formed that he could separate the elasticity of extension from that of compression; by these bars, which were very long and of small depth, he perceived that $\frac{1}{50}$th or $\frac{1}{80}$th of the breaking weight was sufficient to injure the elasticity. He mentioned the matter to his friend Mr. Fairbairn (who was associated with him in the inquiry), soon after he had made the discovery, and Mr. Fairbairn's subsequent experiments, made to determine the strength of rectangular bars of iron, from all parts of the kingdom, were conducted in the same manner as Mr. Hodgkinson's had been; the deflexion and quantity of set, or defect of elasticity, from each weight being always observed. Mr. Fairbairn's experiments were on bars cast one inch square and five feet long, and were made with the utmost care; Mr. Hodgkinson has therefore adopted their results with respect to the "set," and taking means both from Mr. Fairbairn's results and his own, on the same sort of bars, he has sought for the relation between the weights and the mean sets from those weights, these sets being the deflexions or deviations from the original form of the bar after the weights have been removed. To ascertain the relation above, Mr. Hodgkinson had curves described from the results of the experiments, making the sets the abscissæ and the weights the ordinates, and the similarity in appearance of these curves to the common parabola led him carefully to examine whether they were not in reality represented by that curve. The examination was successful, the parabola was the curve, and the mean results of the observed set, together with the calculated ones, from equal additions of weight, from 112 to 448 lbs., derived from eighteen different kinds of iron, and about forty experiments, are below:—

Weights	112	168	224	280	336	392	448
Mean sets, or defects of elasticity	·012	·026	·044	·068	·098	·137	·192
Calculated sets from parabola ...	·012	·026	·046	·075	·104	·142	·186

The following table contains the mean results from forty-four kinds of cast iron and from 90 to 100 experiments:—

Weights	56	112	168	224	280	336	392	448
Mean sets	·003	·013	·026	·047	·069	·102	·136	·197
Computed sets..............	·003	·012	·027	·047	·072	·102	·138	·181

Mr. Hodgkinson made experiments on stone, timber and wrought iron, and observed the quantity of set in all. These different materials, when the results from them were constructed, all gave the form of the parabola, though less perfectly than in cast iron, as the experiments on them were but few.

It appears from the above-stated experiments, and others that were made, that the sets produced in bodies are as the squares of the weights applied. Hence there is no weight, however small, that will not produce a set and permanent change in a body. All bodies when bent have the arrangement of their particles altered to the centre; and when bodies, as the axles of railway carriages, are alternately bent, first one way and then the opposite, at every revolution, we may expect that a total change in the arrangement of their particles will ensue. It appears, too, from the results of these experiments, that all calculations hitherto made on the strength and elasticity of bodies have been only approximations. Mr. Hodgkinson stated that he laid the results of this communication before a meeting of the Literary and Philosophical Society of Manchester a short time ago, soon after he had made the discovery which it contains. In the prosecution of the experiments he had received every assistance which the works of his friend Mr. Fairbairn could supply; and Mr. Robert Rawson had kindly assisted him in the reduction and arrangement of the results of the experiments.

On the Principles of Construction adapted to the perfection of the Flute. By Cornelius Ward.

The author exhibited a flute of a new construction, intended to combine the utmost theoretical completeness of tone and adaptability to musical ratios, with unusual facilities for delicate and varied execution. He presented a memoir in illustration of these peculiarities.

CHEMISTRY.

On the new metals, Lanthanium and Didymium, which are associated with Cerium; and on Erbium and Terbium, new Metals associated with Yttria. By Professor C. G. Mosander. *Communicated by* N. L. Beamish, *F.R.S.*

Although in consequence of the imperfect nature of the results which were obtained from my researches on cerium and lanthanium I had no intention of making any communication on the subject on the present occasion, yet after hearing the interesting statement of Professor Scheerer, it appeared to me that it might be useful to make known more generally some particulars which arose during my labours, and principally because this advantage may result, that other chemists, after becoming acquainted with what I am about to state, may possibly be spared the loss of valuable time which might otherwise have been fruitlessly expended.

When, sixteen years since, I made some experiments upon cerium, several circumstances occurred which led me to the supposition that oxide of cerium was accompanied by some other oxide, which, however, I did not succeed in separating, and want of materials prevented me from then prosecuting the inquiry. A few years since, having procured a quantity of cerite and cerine, I prepared from thence the double salt of sulphate of the oxide of cerium with sulphate of potash, which salt was washed with a solution of sulphate of potash, until the passing fluid gave no trace of precipitate with caustic ammonia or carbonate of soda. I believed that in this manner I could obtain a pure salt free from all foreign substances. The double salt was afterwards decomposed in the moist way with carbonate of soda, and with the carbonate of protoxide of cerium thus obtained, all the preparations have been made which will be now mentioned.

After a long examination of various salts of protoxide of cerium, I did not succeed in detecting a salt principally consisting of the supposed new oxide, the presence of which, however, appeared more and more probable in the course of the experiments. As it was known that cerium gives two oxides, I considered it probable that if hydrate of protoxide of cerium mixed with water was exposed to the effect of chlorine, peroxide of cerium would be formed while the more electro-positive metallic oxide would be dissolved in the fluid, and it was in this manner that I succeeded to my satisfaction. When the chlorine was introduced into the fluid, the appearance of the hydrate of protoxide of cerium began soon to change, the volume diminished, and a heavy, bright, yellow, or rather orange-yellow coloured powder fell to the bottom. If, after the chlorine no longer appears to cause any change, the fluid is filtered, a colourless solution, with the strong odour of hypochlorous acid, is obtained, from which, with hydrate of potash in excess, a precipitate is deposited, which collected on a filter, is white, or approaching violet. This precipitate begins soon, however, to grow yellow in contact with the air. If the precipitate be again mixed with water and chlorine introduced, the greater part is dissolved, while a new portion of the yellow-coloured oxide is formed, and remains undissolved. The filtered solution forms a precipitate again with caustic potash, which is treated as before with chlorine, and this is repeated five or six times, when, finally, hydrate of potash precipitates from the solution an oxide which does not become in the least yellow by exposure to the air, and which suspended in water, is completely dissolved by the introduction of chlorine without leaving a trace of undissolved yellow oxide. It was to this oxide, not capable of being more oxidized either by the air or chlorine, that I gave the name of oxide of Lanthanium, after the production of which, and a nearer acquaintance with its properties, another and simpler method was employed to obtain it. The strong basic qualities of the new oxide afforded an easy means of separating it from oxide of cerium, by treating the red-brown oxide which is obtained when the so-called nitrate of protoxide of cerium is heated with nitric acid diluted with 75 to 100 parts of water. An acid thus diluted leaves the greater part of the red-brown oxide undissolved, and from the solution thus obtained the oxide of lanthanium was derived which was employed by me in the experiments that I made in the beginning of the year 1839. Some of the results which I obtained unfortunately became known to the public. When we find the oxide of a body hitherto unknown, nothing, generally speaking, is easier than the determination of the qualities of the body, and I therefore expected to be able to give a complete account of my experiments in a very short time, but on this point I was much deceived. That which, in the first place, gives any value to chemical investigation, is the certainty that the object investigated is pure, that is to say, free from foreign substances. I had not made much progress in the details of my inquiry, when it appeared that what I at first considered to be pure oxide of lanthanium, was, in point of fact, a mixture of the new oxide with a number of other substances, so that in the course of the experiments I succeeded in separating no less than seven different substances, one after the other. The first, to my great surprise, was lime, in no considerable quantity; and I have found that sulphate of lime and sulphate of potash forms a double salt sparingly soluble. Afterwards the following oxides were successively separated, and by the application of different means, namely, oxide of iron in large quantities, of copper, tin, nickel, cerium, and something resembling uranium, &c.; but even the oxide which remained after the separation of all these substances, left me in nearly the same position which I held at the commencement of the researches, so that, although at the end of the year 1839 I had already been fortunate enough to obtain oxide of lanthanium tolerably pure, it was not until the beginning of the following year that I was able, with any facility, to obtain a larger quantity of it; but, notwithstanding all my efforts, I have not yet succeeded in discovering any method of separating, with any degree of analytical accuracy, lanthanium from cerium, &c.

Oxide of lanthanium, as pure as I have hitherto been able to obtain it, possesses the following properties:—It is of a light salmon colour, or nearly white, but not in the least reddish or brown, and retains its appearance unchanged when heated either in open or close vessels at a red or white heat: the slight colour seems to proceed from a small remnant of some foreign substance. The oxide, although just previously ignited to a white heat, soon changes its appearance in water, becomes snow-white, more bulky, and after twenty-four hours in the ordinary temperature of the air, becomes changed to a hydrate easily suspended in water. With boiling water this change takes place very quickly, and begins immediately; the newly heated oxide as well as the hydrate immediately restores the blue colour to moist reddened litmus paper. Oxide of lanthanium is easily dissolved by acids even much diluted. Salts, when they are formed by the combination of the oxide of lanthanium with uncoloured acids, are absolutely colourless, as well as the most concentrated solutions of the same. Salts of lanthanium have a sweet, slightly astringent taste, and the solution of them can be completely separated from oxide of lanthanium by the addition of sulphate of potash in sufficient quantity, because the double salt formed by sulphate of oxide of lanthanium and sulphate of potash is quite insoluble in a solution saturated with sulphate of potash. The atomic weight of oxide of lanthanium, as it has hitherto appeared in most instances, has oscillated about 680, a number which, however, possesses no scientific value, when, as I have already remarked, an absolutely pure oxide has not yet been obtained.

Of the salts produced, I will only briefly describe a few of the most characteristic.

Sulphate of oxide of lanthanium crystallizes in small six-sided prisms terminated by six-sided pyramids, containing three atoms of water of crystallization. This salt has the same property as sulphate of yttria, thorina, and other oxides of the same class, namely, being much less soluble in warm than in cold water. At 73°·4 Fahr. one part of anhydrous sulphate of oxide of lanthanium requires $42\frac{1}{2}$ parts of water to be dissolved, but of boiling water one part of the same salt requires about 115 parts.

The crystals are very slowly dissolved, but the anhydrous salt is immediately dissolved. The anhydrous salt developes much heat when mixed with a little cold water, and the salt then forms a crystalline crust, which afterwards is very slowly dissolved. If powdered sulphate of oxide of lanthanium be thrown into water whose temperature is 35°·6 or 37°·4 Fahr., and kept stirring, and with the precaution that the liquid, which besides should be cooled from the outside, never attains a higher temperature than 55°·4 Fahr., one part of sulphate of oxide of lanthanium may be dissolved in less than six parts of water, and the solution preserved unchanged for weeks, in closed vessels, and within the stated limits of temperature; but if the liquid be gradually heated, then before the temperature has reached 86° Fahr., a number of crystalline groups composed of small needles radiating from a common centre begin to deposit, and when once this crystallization has commenced it cannot be checked, however rapidly we may cool the liquid. With regard to the number and form of the deposited groups, the originally clear liquid is changed in a few minutes to a thin pap. If during the dissolution of the salt according to the manner stated, a part of the liquid acquires a higher temperature through the heat that is developed by the union of the salt with water, the crystallization of a part of the salt immediately begins, and after that has once begun the phænomenon continues even with so low a degree of heat as 55°·4 to 57°·2 Fahr. less, until the solution only contains $\frac{2}{87}$ths of its weight of anhydrous salt. The salt which has thus been deposited contains the same quantity of water as that which is formed during the evaporation, as well under 55°·4 Fahr. as with 212° Fahr. If sulphate of oxide of lanthanium be kept at a white heat for an hour, it loses the half of its sulphuric acid, and the basic salt which is produced is insoluble in water.

Nitrate of oxide of lanthanium is a salt easily soluble in water or alcohol, and from an evaporated solution of the consistence of thin syrup, it crystallizes in large prismatic crystals, which rapidly deliquesce in damp air. If the solution be evaporated with a heat of 86° Fahr. and above, an opake milk-white mass is obtained. If the salt be cautiously heated so that all the water is expelled, then by care with a higher degree of temperature, the anhydrous salt may be melted without decomposition, and after cooling it resembles a colourless glass; but with the least inattention respecting the temperature, a part of the nitric acid is expelled, and the melted mass is a mixture of neutral and basic salt, which stiffens to a snow-white opake mass, which a moment after solidification has the remarkable quality of falling asunder into a voluminous white powder, with such violence, accompanied by a sort of slight detonation, that parts of it are thrown about to the distance of several inches.

Oxide of lanthanium has a particular tendency to form basic salts, and only such are precipitated with caustic ammonia, let this be added in as great an excess as may be, when also it occurs that the combination with some organic acids, such as tartaric acid, is dissolved in an excess of ammonia. Several of the basic salts, for example, basic nitrate of oxide of lanthanium, and basic chloride of lanthanium, are marked by the quality that they cannot be washed upon a filter with water, which runs through of a milky colour, until no part of the precipitate remains upon the filter, and if the liquid be boiled with the precipitate which has been obtained, the whole runs immediately through the filter. If the precipitate be allowed to remain a few days wet upon the filter, it becomes changed into a neutral salt which is dissolved in the water, and carbonate of oxide of lanthanium, which remains upon the filter.

With regard to cerium, my investigations are as imperfect in their results as those upon lanthanium; I will, however, make mention of some facts which may prove interesting for the present.

The reddish-brown powder which remains after the extraction of oxide of lanthanium with dilute nitric acid, is a mixture of the oxide of cerium with oxide of lanthanium, together with all the above-named accompanying substances. I have not been able to find any good method of obtaining pure oxide of cerium; the salts of protoxide of cerium are like those of oxide of lanthanium, perfectly colourless, and with sulphate of potash the protoxide of cerium is precipitated completely from the solution. If hydrate of protoxide of cerium, precipitated by caustic potash, be collected on a filter, it immediately begins to grow yellow, and after the oxidation has proceeded as much as possible in this manner in the air, there remains after drying, opake light yellow lumps, which contain water; this being expelled by heat, leaves so-called oxide of cerium, which has not the least trace of brown, but after an hour's heating at a white heat, has a slight tinge of red. If the oxide of cerium formed in the manner stated has the slightest tinge of brown, or becomes dark after drying or heating, it proceeds from foreign substances. This yellow oxide, however, always contains protoxide of cerium, and I have not succeeded in obtaining oxide of cerium free from protoxide. The bright yellow oxide which is formed when hydrate of protoxide of cerium, either alone or mixed with hydrate of oxide of lanthanium, &c., is exposed to the action of chlorine, contains not only chlorine but even protoxide of cerium. If nitrate of protoxide of cerium be heated, a light yellow powder is obtained, from which much salt of protoxide of cerium may be extracted with nitric acid, and if this solution be again evaporated, and the dried mass heated, salt of protoxide of cerium is again obtained, and this continues even after the operation has been five times repeated. What I call oxide of cerium is, therefore, really a combination of oxide of cerium with protoxide. The ignited oxide of cerium is scarcely affected by boiling concentrated muriatic acid, still less by other weaker acids; the hydrate, on the other hand, is easily dissolved in muriatic acid, with the development of chlorine, but even after a long boiling the solution retains a yellow colour. Scarcely a trace of the hydrate of oxide of cerium is dissolved by weaker diluted acids, but it assumes a darker yellow colour, and combines with a portion of the acid employed. In the solutions of carbonated alkalies, particularly carbonate of ammonia, the hydrate of oxide of cerium is dissolved in large quantities, and the solution assumes a bright yellow colour. Peroxide of cerium in solutions which are heated to boiling, is immediately reduced by oxalic acid to protoxide of cerium, while carbonic acid is developed. By means of warm concentrated sulphuric acid, the ignited oxide of cerium is immediately rendered soluble, in consequence of combining with the acid. Neutral sulphate of oxide of cerium is, when dry, a beautiful yellow, becomes by heating orange yellow, with a higher degree of temperature almost cinnabar red, but after cooling the bright yellow colour returns. The salt is soluble in a small quantity of water, but if the solution be heated to boiling, the greater part of the salt is deposited in the form of a tough, soft, semi-transparent, and very viscid mass. If the concentrated solution, which is red yellow, be diluted, it becomes lighter yellow, but begins immediately to grow turbid, depositing a sulphur-yellow powder, which is a basic salt requiring 2500 parts of water for its solution. With sulphate of potash, sulphate of oxide of cerium gives a beautiful yellow salt, which is altogether insoluble in a saturated solution of sulphate of potash, but the double salt cannot be dissolved in water without being decomposed and a basic salt precipitated. Notwithstanding the oxide of cerium is nearly insoluble in diluted acids, it must be remembered that intimately mixed with other easily soluble oxides, it readily passes into solution: sulphuret of cerium is of a dark brown-red colour.

The oxide of lanthanium which was first obtained by me was of a brown colour, but after having been heated to a white heat, became a dirty white; by heating in hydrogen it also lost its brown colour, although a scarcely perceptible loss of weight arose therefrom: by heating in the air, the brown colour returned.

This circumstance, together with several other phænomena which presented themselves during the examination of the properties of oxide of lanthanium, caused me to presume that the oxide of lanthanium which had been obtained was still accompanied by some unknown oxides, and it was in the beginning of 1840 that I succeeded in freeing lanthanium from that very substance which caused the brown colour. To the radical of this new oxide I gave the name of *Didymium* (from the Greek word δίδυμος, whose plural δίδυμοι signifies twins), because it was discovered in conjunction with oxide of lanthanium. It is the oxide of didymium that gives to the salts of lanthanium and cerium the amethyst colour which is attributed to these salts; also the brown colour which the oxides of the same metals assume when heated to a red heat in contact with the air. Notwithstanding all possible care, I have not yet succeeded in obtaining the oxide in a state of purity; and I have only arrived so far as to ascertain that a constant compound with sulphuric acid can be produced by different means, but from the quantity of water of crystallization, and other circumstances, the conclusion may be drawn that the salt is really a double salt, although I cannot at present say whether the other accompanying oxide is oxide of lanthanium or some other. That which I now thus briefly describe as oxide of didymium is the basis in combination with sulphuric acid in that salt whose properties I will now communicate, as well as a method of obtaining it. The sulphate of oxide of didymium, prepared in different ways, is much more soluble in water than the sulphate of oxide of lanthanium. This circumstance induced me to try whether by treating the mixture of the anhydrous salts in great excess with water in small proportions, solutions could not be obtained, which, in the order they had been procured, should be richer in salts, and particularly in sulphate of oxide of didymium, while, on the contrary, what remained undissolved, should be nearly pure sulphate of oxide of lanthanium; but after having examined five successive saturated solutions, obtained from the same mixture of anhydrous salts, it was found that one part of anhydrous salt had in the first experiment been dissolved in 7·64 parts of water; in the 2nd experiment in 8·48 parts; in the 3rd experiment in 7·8 parts; in the 4th experiment in 5 parts, and in the 6th experiment in 7·44 parts of water. These remarkable proportions of salt dissolved I thus explained: during the dissimilar degrees of temperature which accidentally arise under the development of heat which takes place when, by the addition of water to the anhydrous salt, this takes up water of crystallization, salts containing unlike portions of water of crystallization, and of unlike solubility had been formed, and it was for the purpose of ascertaining the correctness of this supposition that I afterwards prepared the solution of the salts in the manner which I have already stated in describing the sulphate of oxide of lanthanium, the dissimilar solubility of which salt with different degrees of heat was in this manner discovered. If therefore the mixed salts, with a temperature which should not exceed 48°·2 Fahr., be dissolved in 6 parts of water, and the solution thus obtained afterwards heated to 104° Fahr., a quantity of light amethyst-coloured salt of lanthanium is deposited, which, by a repetition of the same treatment, after ten to fifteen operations, becomes colourless and nearly pure. The amethyst-coloured solution separated from the salt of lanthanium is evaporated to dryness, and the salt is freed from water; it is again dissolved in the before-mentioned manner, but the solution is now heated to 122° Fahr., and filtered after no more salt is deposited. The solution, now red, is diluted with an equal weight of water, acidulated with a portion of sulphuric acid, and is evaporated in a warm place. Several kinds of crystals are now formed, many of which assume a larger size, and fall to the bottom; when only a sixth part of the liquid, which is generally yellow, remains, it is poured off, the salt crust which lies at the bottom is separated, and the collection of crystals is shaken in boiling water, which is suddenly poured off, when a number of smaller prismatic crystals accompany it. The remaining large red crystals are again dissolved in water, the solution is acidulated with sulphuric acid, evaporated in the before-named manner, and the large red crystals taken separately, when it will be found on a nearer examination that they form a mixture of two kinds: the one, which appear in the form of long, narrow rhomboidal prisms, is taken out, and the remaining large red crystals with many planes, which, according to Wallmark's measurement, appear to belong to the triklinometric system, form the salt which I call sulphate of oxide of didymium. From a solution of a salt of didymium hydrate of oxide of didymium is precipitated with hydrate of potash in excess, and collected on a filter; it has a bluish-violet colour, absorbs during washing carbonic acid from the air, and the residuum, for the most part formed of carbonate of oxide of didymium, is, after drying, light reddish violet. If this be heated to redness, the water passes off and carbonic acid is easily expelled. The oxide produced in this manner is obtained in the form of small lumps, dark brown on the surface, sometimes light brown in the fracture, of a resinous lustre, sometimes nearly black, with the lustre and appearance of dark orthite, at the same time particles are obtained of all the most dissimilar colours, so that they represent together a pattern map of all the most dissimilar kinds which are obtained of the mineral orthite, from the light red brown to the nearly black. The powder becomes light brown. If this oxide be heated to a white heat, it assumes a dirty white colour approaching gray green. Oxide of didymium is a weaker basis than oxide of lanthanium: it has no alkaline reaction, and appears not to absorb water after having been heated. It is, however, tolerably easily dissolved even in diluted acids, and the brown oxide with a development of gas. It is insoluble in carbonate of ammonia; its salts are amethyst-red, as well as the solutions of the salt, which forms no precipitate with hydrosulphuret of ammonia, unless a large quantity be added, or the liquid be heated, when the sulphuretted hydrogen is developed, and a basic salt precipitated having a slight tint of red. If the oxide be dissolved in phosphoric salt by means of the blowpipe, the bead becomes amethyst-coloured with great tendency to violet, exactly as with a trace of titanic acid after reduction.

Oxide of didymium heated upon platina foil with carbonate of soda, melts to a gray-white mass. With regard to the salts of didymium, I shall briefly describe those which are analogous to the before-mentioned salts of lanthanium and cerium, and must at the same time mention that the basic salt of didymium which is precipitated by caustic ammonia, can be washed without passing through the filter.

The mode in which sulphate of oxide of didymium is obtained, as well as its appearance, has been already stated; this salt is readily soluble in water at the ordinary temperature of the air, although the crystals are very slowly dissolved. The anhydrous salt is at once dissolved, if before the solution it is not suffered to combine with water of crystallization. Should this occur in such a manner that the anhydrous salt is covered over (*öfver gjutes*) with a little water, the mass becomes heated, and a hard salt crust is formed, which must be reduced to powder before it can be quickly dissolved. At the ordinary temperature of the air, one part of anhydrous sulphate of oxide of didymium requires five parts of water for solution. This solution begins at 127°·4 Fahr. to deposit crystals, the number of which increases in the same degree as the temperature increases, so that the boiled solution contains only one part of anhydrous salt to 50·5 parts of water; at a low red heat an inconsiderable quantity of sulphuric acid goes off, but after an hour's exposure to a white heat, the salt loses two-thirds of its acid. With sulphate of potash, sulphate of oxide of didymium gives an amethyst-coloured double salt, which is completely insoluble in a saturated solution of sulphate of potash.

Nitrate of oxide of didymium is very soluble in water, crystallizes with difficulty; the solution evaporated to thin syrup, has a beautiful red colour, which seen in a certain direction approaches blue. If the salt be evaporated to dryness in a warm place, and heated to melting, which cannot be effected without a great portion of the nitric acid being decomposed, a red fluid is obtained, which, cooled and solidified, does not fall to powder with violence, like the corresponding salt of lanthanium, but retains its form.

I must not omit to mention on this occasion, that amongst the many other bodies which in the course of these researches I was obliged to examine, yttria also presented itself, and I have found that this earth, free from foreign substances, is perfectly colourless, and gives perfectly colourless salts: that the amethyst colour which the salts generally present comes from didymium, I will not, however, maintain.

Addendum, July 1843.—*On Yttria, Terbium and Erbium.*

I published last summer a short notice of yttria, concerning which earth the following facts subsequently discovered merit attention. When I stated on the former occasion that pure yttria, as well as the salts of that base with a colourless acid, are colourless, my experiments had only gone so far as to show that all the yttria which I could procure for examination might with ease be separated into two portions, the one a stronger and colourless base, the other a weaker, which, in proportion as it was free from yttria, acquired a more intense yellow colour on being submitted to heat, and with acids gave salts of a reddish colour. I continued my examination during the following autumn and winter, and thereby was not only enabled to confirm the correctness of my former observations, but made the unexpected discovery that, as was the case with oxide of cerium, what chemists have hitherto considered as yttria, does not consist of one oxide only, but is for the most part to be regarded as a mixture of at least three, of which two appear to be new and hitherto unknown, all possessing the greater number of their chemical characters in common, for which reason chemists have so readily overlooked their real differences.

The characters which are peculiar to these oxides, and distinguish them from all others, are,—1st, that although powerful salt bases, all more so than glucina, they are insoluble in water and in caustic alkalies, but on the other hand soluble, even after having been exposed to a strong heat, in a boiling solution of carbonate of soda, although after a few days the greater part separates from its solution in the form of a double salt; 2ndly, that combined with carbonic acid, they are largely soluble in a cold solution of carbonate of ammonia, and that when such solution is saturated with them, a double salt of carbonate of ammonia and the above carbonates immediately begins to separate, and that in such quantity, that after a few hours very little oxide remains in solution; which explains the observations of several chemists, that, as they express themselves, yttria sometimes dissolves freely, sometimes scarcely at all, in carbonate of ammonia: further, that the salts of these oxides have a sweet taste, and that the sulphates dissolve with more difficulty in warm than in cold water, without its following that they form double salts with sulphate of potash, which are insoluble in a saturated solution of the latter.

If the name of yttria be reserved for the strongest of these bases, and the next in order receives the name of oxide of terbium, while the weakest be called oxide of erbium, we find the following characteristic differences distinguishing the three substances:—The nitrate of yttria is extremely deliquescent, so much so that if a small portion of a solution of that salt be left for weeks in a warm place, the salt produced will not be free from humidity. The solution of nitrate of oxide of terbium, which is of a pale reddish colour, soon evaporates, leaving a radiated crystalline mass, which does not change in air unless it be very damp. The crystals of sulphate of yttria are colourless, and remain clear and transparent for weeks in air at a temperature varying from 86° Fahr. to 158° Fahr., while a solution of sulphate of oxide of terbium yields by evaporation, at a low temperature, a salt which immediately effloresces to a white powder. Oxide of terbium, the salts of which are of a reddish colour, appears, when pure, to be devoid of colour, like yttria. Oxide of erbium differs from the two former in its property of becoming of a dark orange yellow colour when heated in contact with air, which colour it is again deprived of, with a trifling loss of weight, by heating it in hydrogen gas; and it is to the presence of oxide of erbium that yttria owes its yellow colour, when prepared as hitherto directed: and it is moreover probable, that in all those cases where a colourless yttria has been supposed to have been obtained, the presumed yttria has consisted for the most part of glucina, at least before it was known how to separate the last earth completely.

The sulphate and nitrate of the oxide of erbium are devoid of colour, although the solution of the oxide in acids is sometimes yellow, and the sulphate does not effloresce.

These and a number of other less remarkable differences between the three oxides, appear to me to place beyond a doubt that what we have hitherto obtained and described as yttria, is neither more nor less than a mixture of these three bases, at least such is the case with yttria prepared from gadolinite, cerine, cerite, and orthite, but as I have not yet had the good fortune to discover any tolerably easy or certain mode of obtaining the one or the other oxide chemically pure, I shall confine myself for the present to this short statement of facts.

I proceed to make known two easy methods by which chemists may prove the correctness of the above statements. If caustic ammonia in small quantities at a time be added to a solution of ordinary yttria in muriatic acid, and the precipitate following each addition be washed and dried apart, we obtain basic salts, of which the last precipitated are colourless, and contain yttria only. Going backwards in reverse order from these last, we find the precipitates becoming nearly transparent, reddish, and containing more and more oxide of terbium, while the first precipitates contain the greatest proportion of oxide of erbium, mixed with oxide of terbium and yttria. If a solution of ordinary yttria in nitric acid be treated in the same manner, and the several precipitates be heated separately, the first precipitate will give a dark yellow oxide, the colour of each succeeding one will be paler and paler, till at last a white oxide will be obtained, consisting chiefly of yttria, with a trifling quantity of oxide of terbium. In making these experiments it is of importance that the yttria be free from iron, uranium, &c., a matter of considerable difficulty. It is therefore better to commence precipitating with a weak solution of hydrosulphuret of ammonia, and when the precipitate has no longer a shade of bluish green, then to apply the caustic ammonia as described. A better method in general is to add a portion of free acid to a solution of yttria, and then to drop in a solution of binoxalate of potash, continually stirring till the precipitate no longer redissolves. In a couple of hours a precipitate will form, which is to be separated, and the remaining solution treated as above described, and that as long as any precipitate is formed. If the remaining fluid be then neutralized with an alkali, a small quantity of nearly pure oxalate of yttria is obtained. Of the precipitates the first obtained are most crystalline, and fall quickly, the last more pulverulent, sinking slowly. The former contain most oxide of erbium, mixed with oxide of terbium and yttria; the next contain less oxide of erbium, more of terbium and yttria; while the latter contain more and more yttria, mixed with oxide of terbium. The first precipitates are always reddish, and the last colourless. If a mixture of the oxalates of these bases be treated with a very diluted acid, we obtain first a salt containing mostly yttria, then one richer in oxide of terbium, and the remainder contains principally oxide of erbium. I have even once succeeded in obtaining a double salt of sulphate of potash and sulphate of oxide of erbium (which is with difficulty dissolved in a saturated solution of sulphate of potash), by treating a somewhat concentrated solution of the nitrates of oxide of terbium and erbium with an excess of sulphate of potash.

That much time and labour have been employed in arriving even at the results which I have hitherto obtained, will be evident from the little I have been enabled to make known, particularly when it is considered that one or two grains of yttria have often been divided into nearly a hundred precipitates, which have been individually examined; but I live in hopes that the knowledge already obtained will soon enable me to publish a more complete account of my investigations.

On the Heat of Combination. By Dr. Andrews.

The object of this communication was to announce the following general principle, as a consequence of previous researches of the author on the same subject, and to give a general account of some recent experiments which appear to him to establish its accuracy. The law may be thus stated: "When one base displaces another from any of its neutral combinations, the heat evolved or abstracted is always the same when the base is the same; or, in other words, the change of temperature which occurs during the substitution of one base for another in any neutral compound, depends wholly on the bases, and is in no respect influenced by the acid element of the combination." To test the accuracy of this principle by direct experiment, equivalent solutions of various neutral salts were decomposed by the addition of a dilute solution of the hydrate of potash. When the strength of the solutions and their temperatures were properly adjusted, the same variation of temperature always occurred during the decomposition of salts of the same base. If the base (in the state of a hydrate) developed, when alone, less heat than the hydrate of potash in combining with the acids, an elevation of temperature occurred during the decomposition of its salts by the latter; if the reverse were the case, the decomposition of the salts was attended by a diminution of temperature. Thus the decomposition of equivalent solutions of the salts of the oxide of copper was attended by the evolution of the same amount of heat, as was also the decomposition of the salts of the oxide of zinc; but the heat extracted by the former was about twice as great as that extracted by the latter, because the oxide of copper produces less heat in combining with the acids than the oxide of zinc. The salts of lime furnish an example of an absorption of heat when their solutions are decomposed by potash,—a circumstance easily explained by the fact which has been before established by the author, that the hydrate of lime when combining with the acids developes more heat than the hydrate of potash. But, in accordance with the principle before stated, the diminution of temperature is the same with equivalents of all the salts of lime. In an inquiry of this kind many precautions are requisite, in order to obtain accurate results. Among the most important may be mentioned, the exact neutrality of the salt to be decomposed, a perfect equality of temperature in the solutions before mixture, and the precipitation of the oxide in the state of a pure hydrate, and not of a subsalt.

On the Calorific Effects of Magneto-Electricity, and the Mechanical Value of Heat. By J. P. Joule.

Although it had been long known that fine platinum wire can be ignited by magneto-electricity, it still remained a matter of doubt whether heat was evolved by the *coils* in which the magneto-electricity was generated: and it seemed indeed not unreasonable to suppose that *cold* was produced there, in order to make up for the heat evolved by the other parts of the circuit. The author had endeavoured therefore to clear up this uncertainty by experiment. His apparatus consisted of a small compound electro-magnet, immersed in water, revolving between the poles of a powerful stationary magnet. The magneto-electricity developed in the coils of the revolving electro-magnet was measured by an accurate galvanometer; and the temperature of the water was taken before and after each experiment by a very delicate thermometer. The influence of the temperature of the surrounding atmospheric air was guarded against by covering the revolving tube with flannel, &c., and by the adoption of a system of interpolation. By an extensive series of experiments with the above apparatus the author succeeded in proving that heat is evolved by the coils of the magneto-electrical machine, as well as by any other part of the circuit, in proportion to the resistance to conduction of the wire and the square of the current; the magneto-, having, under comparable circumstances, the same calorific power as the voltaic electricity. Prof. Jacobi, of St. Petersburgh, had shown that the motion of an electro-magnetic engine generates magneto-electricity in opposition to the voltaic current of the battery. The author had observed the same phænomenon on arranging his apparatus as an electro-magnetic engine; but had found that no additional heat was evolved on account of the conflict of forces in the coil of the revolving electro-magnet, and that the heat evolved by the coil remained, as before, proportional to the square of the current. Again, by turning the machine contrary to the direction of the attractive forces, so as to *increase* the intensity of the voltaic current by the assistance of the magneto-electricity, he found that the evolution of heat was still proportional to the square of the current. The author discovered, therefore, that the heat evolved by the voltaic current is invariably proportional to the square of the current, however the intensity of the current may be varied by magnetic induction. But Dr. Faraday had shown that the chemical effects of the current are simply as its quantity. Therefore he concluded that in the electro-magnetic engine, a part of the heat due to the chemical actions of the battery is lost by the circuit, and converted into mechanical power; and that when the electro-magnetic engine is turned *contrary* to the direction of the attractive forces, a *greater* quantity of heat is evolved by the circuit than is due to the chemical reactions of the battery, the overplus quantity being produced by the conversion of the mechanical force exerted in turning the machine. By a dynamometrical apparatus attached to his machine, the author has ascertained that, in all the above cases, a quantity of heat, capable of increasing the temperature of a pound of water by one degree of Fahrenheit's scale, is equal to a mechanical force capable of raising a weight of about 838 pounds to the height of one foot.

On the Decomposition of Carbonic Acid Gas, and the Alkaline Carbonates, by the light of the Sun. By Prof. Draper, *New York.*

The decomposition of carbonic acid gas by the leaves of plants under the influence of the light of the sun, is one of the most remarkable facts in chemistry. Dr. Daubeny, in a very able paper in the Transactions of the Royal Society for 1836, came to the conclusion, that the decomposition in question was due to the ray of light, a result obtained by the agency of coloured glasses, but which does not appear to have been accepted by later authors, who have attributed it to the chemical rays. There is but one way by which the question can be finally settled, and that is by conducting the experiment in the prismatic spectrum itself. When we consider the feebleness of effect which takes place, by reason of the dispersion of the incident beam through the action of the prism, and the great loss of light through reflexion from its surface, it would appear a difficult operation to effect the determination in this way. Encouraged, however, by the purity of the skies in America, I made the trial, and met with complete success. A series of tubes, half an inch in diameter and six inches long, were arranged so that the coloured spaces of the spectrum fell on them. In these tubes, water, impregnated with carbonic acid gas, and containing a few green leaves (*Poa annua*), was placed. It was expected that if the decomposition be due to the radiant heat, the tube occupying the red space, or even the one in the extra-spectral red space, would, at the close of the experiment, contain most gas. If it were the "chemical rays," in the common acceptation of the term, we might look for the effect in the blue, violet, or indigo spaces; but if it were the LIGHT, the gas should make its appearance in the yellow, with some in the green, and some in the orange. I made the trial several times, and found it much more easy to accomplish than I had expected. The results were briefly as follows:—In the tube that was in the red space a minute bubble was sometimes found, but sometimes none at all. That in the orange contained a more considerable quantity; in the yellow ray a very large amount, comparatively speaking; in the green a much smaller quantity; in the blue, the indigo, the violet, and the extra-spectral space at that end, not a solitary bubble. From these facts, in connexion with some results obtained by the use of bichromate of potash as an absorptive medium, I conclude that it is the rays of light which effect the decomposition, and that the rays of heat and the tithonic rays have nothing to do with the phænomenon. The alkaline bicarbonates are easily decomposed by elevation of temperature, yielding a portion of their acid at the boiling point of water. Instead of using a solution of carbonic acid, I endeavoured to effect the decomposition of these salts by leaves in the sunlight, and found that it took place with facility. Nor is the effect limited to the removal and decomposition of the second atom of the acid. It passes on to the first; the neutral carbonate of soda itself decomposing and yielding oxygen gas. In like manner the sesquicarbonate of ammonia may be made to yield a very pure oxygen gas. Dr. Draper, in concluding this communication, alludes to his method of multiplying the Daguerréotype pictures, as published in the Philosophical Magazine, and then mentions a process of precipitating copper, after the picture has been fixed by gold, by the electrotype process, on the plate, which, as he states, gives a very perfect copy. "It is difficult," says the Professor, "to describe in words the beauty and perfection of these 'copper-tithonotypes.' The problem of multiplying the Daguerréotype may be now regarded as completely solved."

On Chromatype, a new Photographic Process. By R. Hunt.

We are indebted to Mr. M. Ponton for the discovery of the first photographic process in which chromic acid was the active agent. He used a paper saturated with the bichromate of potash, which, on exposure to sunshine, speedily passed from a fine yellow colour into a dull brown, giving, consequently, a negative picture. E. Becquerel improved upon this process, by sizing the paper with starch previously to the application of the bichromate of potash, which enabled him to convert the negative picture into a positive one by the use of a solution of iodine, which combined with the starch in those parts on which the light had not acted, or acted but slightly, forming the blue iodide of starch. These pictures are, however, tediously produced; they are seldom clear and distinct, and failure too frequently follows the utmost care. While the author was pursuing an extensive series of researches on the influence of the solar rays on the salts of different metals, he was led to the discovery of a process by which positive photographs are very easily produced. Several of the chromates may be used in this process; but the author prefers those of mercury or copper, the most certain effects being produced by the chromate of copper, and, indeed, in a much shorter time than with any of the other chromates. The papers are thus prepared: good writing-paper is washed over with a solution of the sulphate of copper and partially dried; it is then washed with a solution of the bichromate of potash and dried at a little distance from the fire. Papers thus prepared may be kept for any length of time, and are always ready for use. They are not sufficiently sensitive for use in the camera obscura, but they are available for every other purpose. An engraving—botanical specimens or the like—being placed upon the paper in a proper photographic copying-frame, it is exposed to sunshine for a time, varying with the intensity of light from five to fifteen or twenty minutes. The result is generally a negative picture. This picture is now washed over with a solution of nitrate of silver, which immediately produces a very beautiful deep orange picture upon a light dun colour, or sometimes perfectly white ground. This picture is quickly fixed by being washed in pure water and dried. The author remarked that, if saturated solutions were used, a negative picture was first produced, but if the solutions were diluted with three or four times their bulk of water, the first action of the sun's rays was to darken the paper, immediately upon which a very rapid bleaching action followed, giving an exceedingly faint positive picture, which was brought out in great delicacy by the nitrate of silver. It is necessary that pure water should be used for the fixing, as the presence of any muriate damages the picture, and hence arises another pleasing variation of the chromatype. If the positive picture be placed in a very weak solution of common salt, the images slowly fade out, leaving a very faint negative outline. If it be taken from the solution of salt and dried, a positive picture of a lilac colour may be produced by a few minutes' exposure to sunshine. Prismatic analysis has shown that the changes are produced by a class of rays, which lie between the least refrangible blue, and the extreme limits of the violet rays of the visible prismatic spectrum—the maximum darkening effect being produced by the mean blue ray, whilst the bleaching effect appears to be produced with the greatest energy by the least refrangible violet rays.

On the Influence of Light on the Growth of Plants. *By* R. Hunt.

The peculiar influence exerted upon the germination of seeds, and the growth of the young plants by coloured light, has been for some years the subject of the author's investigations. The results show the surprising powers exerted by the more luminous rays in preventing germination, and in destroying the healthful vigour of the young plant. Plants, when made to grow under the influence of the red rays, bend from the light as something to be avoided; while the blue or chemical rays are efficacious in quickening the growth of plants. Since the publication of the last Report, the author has tried plants of a great variety of kinds, and the same effects have been produced. It has, however, been found, that although blue light accelerates germination, and gives a healthful vigour to the young plant, its stimulating influences are too great to ensure a perfect growth. The strength of the plant appears to be expended in the production of a beautiful deep green foliage; and it is only by checking this tendency, by the substitution of a yellow for a blue light, that the plant can be brought into its flowering and seeding state. The etiolating influence of the green rays was observed, as well as the power which plants possessed of sending out shoots of a great length, in search of that light which is essential to their vigour.

On the Influence of Light on a great variety of Metallic and other Compounds. *By* R. Hunt.

The author, having briefly detailed the numerous discoveries in this branch of inquiry, from the time of the alchymists to the present day, proceeded to describe the results of his experiments, made with nearly every variety of chemical combination. It was not with the view of establishing any theory relative to the solar agency, that this matter was brought before the Section, but merely to put upon record a great number of facts, which appear to prove the constant acting of the sun's rays upon all bodies, and to show the boundless extent of this inquiry. It has been shown by Petit, that light influences the arrangements of crystals. Labillardière and Michelotti have shown the necessity of light to the development of pores in plants, and its injurious influence on young plants and animals. The experiments of Ritter and others, down to the time of Niepce and Daguerre, have shown many peculiarities in the action of this agent. But since that period the list has been wonderfully increased by the researches of Wollaston, of Davy, of Fox Talbot, and, above all, by the extraordinary discoveries of Sir John Herschel. We are now acquainted with combinations of silver, of gold, of mercury, of iron, and many non-metallic bodies, which are speedily changed under the sun's influence, and which are sufficiently sensitive to be used as photographic agents. The author has been successful in adding platinum to the list; which metal gives considerable promise of utility in the art. He has also been successful in producing photographic images on the salts of manganese, of tin, of antimony, of lead, of cobalt, and of arsenic. He has produced pictures with chlorine, iodine, and bromine vapours received upon the surfaces of a great variety of metals, and even on wood and on leather; and many of the alkaline and earthy salts have given evidence of this extraordinary property of the sun's rays. The author contended, that from the extensive series of results which he had obtained, he was fully warranted in expressing it as his opinion, that all bodies were constantly, under the influence of the solar emanations, undergoing a change of state; that, indeed, photographic images were always formed, on whatever body a shadow fell: we were only ignorant of the reagents by which these images could be called forth; but we were rapidly arriving at the knowledge we desired.

On a new Method of testing the Hygrometric Formula usually applied to Observations made with a wet and dry Thermometer. By J. APJOHN, *M.D.*

Some years ago Professor Apjohn communicated to the Royal Irish Academy a formula for inferring what is called the dew-point, from observations of the wet and dry thermometers alone, and he considered the accuracy of his formula as fully established by three experimental tests, which he explained in a memoir read to the same learned body. "But finding," he says, "that some still doubted, I thought it might be as well to give publicity to a fourth method of verification which I have lately employed, and which has in the fullest manner sustained the general conclusion to which the previous test experiments had conducted. It is well known that if unity represents the specific gravity of dry atmospherical air at the temperature of 60°, and under a pressure of 30°, that its specific gravity at the temperature t'', and under the pressure f'' will be represented by the expression

$$\frac{521}{461 + t''} \times \frac{f''}{30}.$$

Now if we suppose the air at t'' to be saturated with moisture whose elastic force is f'', the specific gravity of the aqueous vapour will be $\frac{521}{461 + t''} \times \frac{f''}{30} \times \cdot 625$, the latter factor being the density of vapour in relation to air, having the same temperature with it, and existing under the same pressure. The air, however, being not at its dew-point, but at some higher temperature t, in order to obtain the specific gravity of the vapour at this latter temperature, the expression already got must be multiplied by $\frac{461 + t''}{461 + t}$, by which it will become $\frac{521}{461 + t} \times \frac{f''}{30} \times \cdot 625$. This, then, is the exact specific gravity of aqueous vapour in air, whose temperature is t, and whose dew-point is t''. And multiplying this by $\cdot 31\ v$, $\cdot 31$ being the weight of one cubic inch of atmospheric air, and v the volume, or number of cubic inches of air,

$$\frac{521}{461 + t} \times \frac{f''}{30} \times \cdot 625 \times \cdot 31\ v = \frac{3 \cdot 3647 f''}{461 + t} \times v$$ is the weight of v cubic inches of aqueous vapour whose maximum tension is f'', and existing in v cubic inches of air whose temperature is t. Let us suppose this quantity to be determined by experiment, and to be represented by w. Then

$$\frac{3 \cdot 3647 f''}{461 + t} \times v = w, \text{ and } f'' = \frac{w}{v} \times \frac{461 + t}{3 \cdot 3647}.$$

Knowing therefore w, which may be got very accurately by experiment, we can calculate f''. But, by the hygrometric formula, $f'' = f' - \frac{t - t'}{87} \times \frac{p - f'}{30}$, this latter value should, of course, be equal to the former; and without detaining the Section with the actual numbers which I have obtained, I may state that the method just explained has completely established the accuracy of the expression which gives the force of vapour at the dew-point in terms of the difference of temperatures of the wet and dry thermometer, of the pressure of the air, and of the tension of vapour at the temperature indicated by the instrument, whose bulb is kept moist.

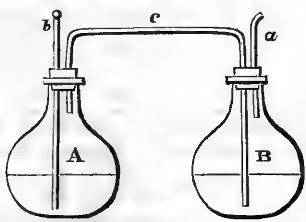
"I have only in conclusion to state, that the quantity *w* is got by slowly passing, by means of an aspirator, a known volume of atmospheric air through a system of two tubes, one of which is packed with small fragments of chloride of calcium, and the other with asbestos moistened by oil of vitriol."

Some Remarks on the Chemistry of the Arsenites. By J. APJOHN, *M.D.*

This paper contained an account of a variety of experiments, made with the view of obtaining a more exact knowledge of the arsenites than can be acquired from books. The substances chiefly experimented on were arsenite of copper, arsenite of lime, and arsenite of silver.

Abstract of a Letter from Dr. Will of Giessen, on an Improved Method of ascertaining the commercial Value of Alkalies or carbonated Alkalies, Acids, and Oxides of Manganese.

The apparatus by which this determination is effected consists of two small glass flasks (A and B), connected by the bent tube *c*, which passes through corks in the necks of the flasks. Into the flask A is put the solution of the substance to be tried, and into B is put concentrated sulphuric acid. Two other tubes pass through the corks in the flasks—the one, passing through the cork of A, dips below the surface of the solution, and is closed with a small piece of wax, while the one in B is left open, and does not reach below the fluid contained in it. Suppose the flask A to contain a weighed quantity of a solution of a carbonate, then a known quantity of sulphuric acid is introduced into B, and the whole apparatus weighed: the tube *b* being then closed with wax, if air be blown into *a*, a portion of the sulphuric acid passes over through the tube *c* into the flask A, and comes in contact with the carbonate. The consequence is an evolution of carbonic acid, which must go through the concentrated sulphuric acid, and is thus made perfectly dry. When all the car-



bonate is decomposed, the piece of wax on the tube *b* is removed, and air sucked through the tube *a*, in order to remove all the carbonic acid. The apparatus is then to be weighed, and, from these data, the quantity of alkali combined with carbonic acid may be easily calculated. The same method is applicable to the acids, particularly to vinegar, which was till now a very tedious and, at the same time, a very inaccurate operation. Dr. Will considers that the value of soda or potash can be thus determined with much greater accuracy than according to the method of Descroizell, improved by Gay-Lussac. If a soda contains a sulphite or a hyposulphite, which is almost always the case, the alkalimetrical method in use at present gives quite wrong results: the same is the case if potash contains phosphates, silicates, &c.

Chemical Suggestions on the Agriculture of Cork. *By* Thomas Jennings.

The author drew attention to the present state of agriculture in the south of Ireland, and to the immense importance of some system by which the value of the limestones and sands of the district might be carefully ascertained by good chemical analysis. Two kinds of limestone were found in the neighbourhood of Cork; the variety which yielded the best lime for building was found to be very inferior to the other as a manure. The sands from the bed of the river Lee, and many of the sea sands were used as manure with very uncertain results. The author suggested the propriety of having correct analyses made, and large masses of the rock, or of the sand, placed in some museum, where the results of careful analysis should be registered.

On the Minerals of Cork. *By* R. W. Townsend.

A series of minerals, all of them collected by Mr. Townsend, was exhibited. This collection included some beautiful specimens of copper pyrites, gray copper, and malachite, manganese ores of a fine character, and some rare iron ores, and may be regarded as giving a fair view of the mineralogical condition of the county.

Mr. Townsend also exhibited a specimen of manganese taken from the deposit formed by a thermal spring near the Cape of Good Hope. The water issued at a temperature of 110°, and so large was the quantity of manganese, which, in some form, it held in solution, that a very thick incrustation lined the stream within a short distance of the spring.

On newly-discovered Three-twin Crystals of Harmotome, so arranged that they form a regular Rhombic Dodecahedron. *By* Dr. F. Tamnau *of Berlin.*

The celebrated Mohs was the first who observed that the modification of the primary form of harmotome was such as could never belong to the pyramidical system, in which it was placed by Werner and his disciples. Messrs. Phillips and Brooke gave measurements of the mineral, and confirmed the idea of Mohs. During a residence in Paris Dr. Tamnau met with a very beautiful three-twin crystal of harmotome, and also in Bohemia, in a basaltic rock in the neighbourhood of Aussig, on the bank of the river Elbe. It was accompanied with small crystals of analcime—little white crystals of chabasite,—and some yellow-brown crystals of carbonate of lime, which specimens were exhibited. Each of these little groups of crystals consists of three single crystals, so arranged that the axes cross each other at angles of 90°. By this arrangement the faces of the pyramid on the one crystal falls exactly together with the faces of the same pyramid of the other crystal; and if those faces were enlarged so much, that the faces of the prism should not be visible, they would give the form of a regular rhombic dodecahedron. Not only are the angles of the pyramid exactly determined independent of any single measurement, but it is also decided that the two angles of the pyramid are of the same value, and consequently that the mineral is not in its primary form of the right *rectangular*, but that it is a right square four-sided prism. And it may at the same time be observed that, however the distribution of the secondary faces may show the harmotome to belong to the prismatic system, we have in it a remarkable instance of a mineral which is pyramidical in its mathematical measurement, and at the same time prismatic in its physical qualities.

Dr. Tamnau, of Berlin, exhibited some rare mineralogical specimens:—1. A group of Datholith, from the neighbourhood of Andreasberg, in the Hartz. 2. Two specimens of rose-coloured Harmotome, from Andreasberg. The colour of these specimens was attributed to the presence of a small quantity of cobalt. They were remarkable for the great size of their crystals, which exhibited not only the usual twins, but also curious and complicated arrangements of three and four, combined according to laws not yet sufficiently understood to allow of their being clearly described. 3. Two very large isolated crystals of Beryl, from Royalstone, Massachusetts. These were of a beautiful sea-green colour, one of them of the usual form, a regular six-sided prism, with the direct terminal face. The other exhibited the faces of the second six-sided prism, of a twelve-sided prism, and of a twelve-sided irregular pyramid. The last of those forms is here observed for the first time.

On the Relative Electro-Negative Powers of Iodine and Fluorine. *By* the Rev. T. Knox.

The object of this paper was to controvert the statement made by Brande in his 'Chemistry,' that the fluorides are not decomposed by chlorine or iodine; and to show, as the result of experiments, that fluorine has been erroneously placed above iodine as a negative element.

On the Electricity of High-Pressure Steam, and a description of a Hydro-Electric Machine. *By* W. Armstrong.

This paper recapitulated the circumstances which first drew the attention of the author to steam as a source of electrical power, and the successive steps by which he had succeeded in arranging apparatus to render it effectual. The powers of the 'Hydro-electric Machine' were described and illustrated by a diagram. The author assents to Dr. Faraday's opinion, that the force with which the particles of water are rubbed against the glass, is in this case the cause of the development of electricity.

On the late Fires at Liverpool, and on Spontaneous Combustion. *By* A. Booth.

This communication consisted of an enumeration of cases in which fires had, as it was supposed, originated in the spontaneous combustion of material used in manufactures; and the author suggested the propriety of instituting an extensive series of experimental inquiries into this class of phænomena, which are but ill understood.

On the Chemical Composition of Smoke, its Production and Influence on Organic Substances. *By* A. Booth, *F.L.S.*

On the Production and Prevention of Smoke. *By* Henry Dircks.

Mr. Dircks, referring in particular to the plans of Mr. C. Wye Williams for the prevention of smoke, thought it important to distinguish between open fires, and close fires or furnaces. Open fires would always allow an escape of absolute coal-gas, and admit atmospheric air to the chimney; whereas the contrary would be the result with the close fires of engine-boiler furnaces. He said that the leading fact of consequence, in reference to the *smoke*, was, that it differed materially from the impure gas evolved from the coal in the furnace. The plans hitherto adopted by manufacturers were chiefly intended to burn smoke, and the prevailing principle of all such plans was to burn the largest quantity of fuel with the least quantity of air. The error of this method must appear to every one conversant with chemistry. Smoke may be considered as mere carbonaceous matter floating in an atmosphere of the ordinary incombustible products of combustion; the admission of air to this smoke is of no value, as it will only cool it, and make it more readily deposit its sooty particles. The impure gas of the coal, on the contrary, may be inflamed by a due admixture of air. In conclusion, Mr. Dircks begged to state as a general principle, that on the large scale of the furnace, air, in as divided a form as possible to favour rapid diffusion mechanically, should be supplied to the impure gaseous products of the fuel independent of the supply of air to the solid fuel on the grate. Mr. Dircks said that the principle he advocated was that practically carried out in the Argand furnaces of Mr. C. Wye Williams.

Eulogium on the late Richard Kirwan, LL.D. *By* Dr. Pickells.

The author traces the progress of this very distinguished philosopher from the period when, by the death of his brother, who was accidentally shot while entering the

Irish House of Commons, he retired from the bar. For his first efforts, a series of essays, he received the Copley medal, and he was elected a Member of the Royal Irish Academy. Chemistry and mineralogy were the sciences to which Mr. Kirwan particularly applied herself. He was fond of metaphysics, and wrote a volume on logic. He also bestowed much attention on meteorology, and his essay on the variations of the barometer has obtained the approbation of Dalton and others.

GEOLOGY AND PHYSICAL GEOGRAPHY.

On the Distribution of Erratic Blocks in Ireland, and particularly those of the North Coasts of the Counties of Sligo and Mayo. By Richard Griffith, *F.G.S.*

If we look to the distribution of erratic blocks as indicative of the direction of the currents by which they were distributed, we find in Ireland generally that they were carried from north-west to south-east, though the current was often modified by the opposition of mountain ridges.

The prevailing component of our drift is rolled limestone and clayey matter, derived from our great limestone field, which occupies two-thirds of the island. This matter is seldom stratified: it consists of an heterogeneous mass of large and small rounded pebbles of limestone, intermixed with clay, fine gravel, and rarely siliceous sand.

This mass often exceeds 100 feet in thickness; it pervades all our valleys, and even the interior of some of our mountain ranges, to a considerable height; it occurs either in one thick mass, resting on the rock, or in the form of those remarkable low, but steep gravel hills called *Eskers*. The prevailing direction of our mountain ridges is from north-east to south-west at right angles to the supposed direction of the current, and, as might be expected, we find the gravel-banks and detritus distributed on the north-western declivities of the hills, and intruding into the interior valleys; the slate districts of Armagh, Cavan, Monaghan, &c. might be instanced.

In some instances, in the granite and slate districts of Wicklow, as in the valley of the Slaney, the limestone gravel has passed through the valleys of the mountain ridge, and has formed a deposit of limestone pebbles, eastward to the range of Mount Leinster, and spread over the slate country in the neighbourhood of Newtownbarry in Wexford.

Similar facts may be observed in the Slievebloom mountains, as well as the Galtees and Monavoullagh mountains of the counties of Limerick and Waterford.

Limestone gravel is found on the western declivities in the valleys of all the mountain ranges mentioned, but none has been observed on the eastern declivities. We may hence infer, that where the mountains were of sufficient height, the currents were interrupted, and the gravel did not pass to the eastward. The summit of the Baltinglass hill in the county of Wicklow is elevated 1256 feet above the level of the sea. Its southern and western declivities are covered by limestone gravel to an elevation of upwards of 800 feet, but none occurs on its eastern declivity. The neighbouring hills of Spinan's and Brusselstown are also covered by limestone gravel to the height of 880 feet; hence we may assume that the transporting force did not exceed an elevation of 1000 feet.

On the top of the gravel deposit, and independent of it in many localities, are found boulders of granite, and red and light gray conglomerate, scattered over the surface of the country, but rarely, if ever included or intermixed with the gravel lying below. Owing to a peculiarity in the composition of granite of certain districts, it is not difficult to detect the locality from which each was derived; hence he had no hesitation in saying that he found small boulders of the granite of Cunnemara in Galway to the east of the Slievebloom mountains, in the line of the valley of Roscrea. Similar boulders, but larger, occur in the King's County, and also in the limestone district of Galway, indicating that the direction of the line of transport was from north-west to south-east through a very large portion of Ireland; this, however, is not universal.

In the county of Sligo are two mountain ridges, the Ox mountains and the Curlew mountains, which have nearly parallel directions; the Curlew range being about twelve miles south of the other. The Curlew mountains consist of reddish-brown sandstone, connected with the Upper Silurian system, and the Ox mountains are composed of mica-slate and granite, the former predominating, and the country situated to the north and south of both ranges is composed of rocks belonging to the Carboniferous system.

In the limestone district south of the Curlew mountains the gravel hills consist of limestone solely; and in a northern direction the gravel banks extend up the southern slopes of the hills of brown sandstone, where numerous pits have been opened to raise the limestone for manure.

Ascending the ridge of the Curlews, we find numerous boulders of yellowish-gray sandstone scattered on the surface. Passing over the summit, and descending to the northward, into the limestone valley of Ballymote and Tobercurry, the surface is thickly covered with boulders of reddish-brown sandstone, some of them weighing several tons, the largest being nearest to the Curlew range. On approaching the base of the Ox mountains the red boulders are still numerous, but diminish in size.

Ascending the mica-slate ridge of the Ox mountains, we still find small boulders of the same sandstone, together with small *eskers* of limestone gravel in some of the valleys. These eskers are remarkable, owing to their forming ridges directly across the valleys. This is particularly the case in the valley of Lough Easky, situated in the middle of the mountain range. To the north and south of this lake the rock is mica-slate, but at the lake there has been an extensive protrusion of large-grained crystalline granite, composed of flesh-red felspar, white felspar, gray quartz and black mica, the mica-slate being metamorphic along the line of contact.

In the line of the road to Easky Lough, two miles south of the lake, the valley is crossed at right angles by two eskers of rolled limestone, varying in size from two to three inches in diameter, mixed with small grains of limestone and a little clay.

The declivities of these eskers are steep, as is usual, and their height may be about thirty feet; their elevation above the limestone plain to the south, whence the limestone of the eskers appears to have been derived, is 250 feet. It is remarkable that numerous large boulders of mica-slate, exactly similar to the rock of the district, are strewed over the surface of these eskers, but none of them are intermixed with the gravel.

Approaching Lough Easky, there is an elongated sinuous esker, nearly parallel to the line of the valley. This differs in its composition as well as direction from those just described. It is composed of pebbles of quartz and mica-slate, intermixed with siliceous sand, the whole being evidently derived from the adjoining mountain. Here is a moraine which may be accounted for according to the hypothesis of Agassiz; and so may also the boulders of mica-slate, which cover the eskers already mentioned, but not the eskers themselves.

Following the valley of Lough Easky in a northern direction to the sea-shore, beyond the village of Easky, for ten miles, the surface of the limestone country, situated to the north of the Ox mountains, is thickly strewed over by large boulders of granite, some of which (close to the sea-shore) are of enormous dimensions; and one, which is cleft through the centre, contains 1360 cubic feet, equal in weight to 100 tons,—a mass which it is difficult to conceive could be moved by water, unless in the form of ice.

The granite of these boulders is identical with that of Lough Easky, hence we must suppose that they were derived from that source.

Similar granite boulders occur along the whole line of coast westward from Easky to Erris in Mayo. A few rolled blocks of metamorphic mica-slate may occasionally be observed, but not one boulder of limestone, though the entire district is composed of carboniferous strata. It may be observed that the whole of these granite boulders are precisely similar in composition to the granite of the Ox mountains, particularly of Lough Easky, Lough Talt, and Foxford.

Taking all these facts together,—namely, the boulders of the brownish-red sandstone covering the surface of the limestone valley between the Curlew and the Ox mountains, the Ox mountains containing eskers of limestone gravel evidently derived from the limestone valley of the south, and the granite boulders of Easky and of the north coast of Mayo derived from the Ox Mountains, also situated to the south,—we arrive at the conclusion, that at least in the localities mentioned the current has been from the south, and *not* from the north-west, as has probably been the case in other districts of Ireland.

On the Lower portion of the Carboniferous Limestone Series of Ireland. By Richard Griffith, *F.G.S.*

Referring to his communication at the Manchester Meeting (Report for 1842), the author stated the subdivisions of the series to be described in the following descending series beneath the millstone grit:—1. The Upper Limestone. 2. The Limestone Shale, or Calp. 3. The Great, or Lower Limestone. 4. The Carboniferous Slate. 5. The yellow or Lower Carboniferous Sandstone.

1. *The Upper Limestone.*—Its average thickness may be about 600 feet. It consists of light gray limestone, alternating near the top with gray flinty slate and occasionally dolomite. The lower beds frequently contain disseminated rounded masses of gray and black Lydian-stone. It presents numerous mural escarpments, many of which are cavernous. It is very fossiliferous, and the fossils correspond nearly with those of the carboniferous limestone of England, though many are peculiar to it.

2. The Calp is distinguished as presenting a succession of beds of dark gray shale, alternating with dark gray impure argillo-siliceous limestone. This group, when perfect, is separable into three parts,—the upper and lower shales, and an intervening yellowish-gray sandstone. The average thickness of the whole may be about 1000 feet, though in some localities it amounts to 1800 feet. It contains numerous fossils; those found in the fine shale beds differ from the upper limestone, the most characteristic being several varieties of Posidonia.

3. The Great or Lower Limestone occupies a large portion of the surface of Ireland. Its colour varies from light to dark gray, and its structure is usually less crystalline than the upper. The lower beds are frequently dolomitic, and occasionally oolitic. This group is more abundant in fossils than either of the foregoing, and contains nearly the whole of those found in the two upper members of the system, with the exception of Posidonia; its average thickness may be about 1000 feet.

4. The foregoing comprehends the whole of what was formerly considered to belong to the carboniferous limestone of Ireland, the strata beneath having been previously included in the Old Red Sandstone; but in his paper of the preceding year, he was enabled to show, by comparing the fossils in the strata below the limestone with those above, that they must be attached to the Carboniferous, and not to the Old Red or Devonian system.

These lower members have been subdivided into two, the carboniferous slate and the yellow sandstone.

The whole list of fossils at present discovered contains 925 species without fishes or plants, of which 359 are new and have been figured (these are exclusive of those contained in the Ordnance Geological Memoir of a part of the North of Ireland, by Capt. Portlock, R.E., published during the present year).

The lower portion of the Carboniferous system of Ireland, to which he has given the name of yellow sandstone, to distinguish it from the old red which lies beneath, is much more fully developed in the North of Ireland than in the South; some very fine sections may be examined in detail on the north coast of Donegal Bay; also on the northern shore of Lower Lough Erne, north-east of Pettigoe; likewise between Balderig Bay and Killala in the county of Mayo; in the valley of Ballinascreen near Maghera in the county of Derry, and many other localities.

He first proceeded to examine the section near Ballycastle in Mayo, and said that the micaceous quartzite, belonging to the mica-slate of Erris, is succeeded unconformably by strata of red sandstone, rather fine-grained, alternating with red and dark green shale, and occasionally with yellowish-gray sandstone and impure gray limestone. These beds are 650 feet thick; the dark gray shales and limestones contain fossils; the shales, Cythere, Modiolæ, Nucula, Cypricardia, &c., many of which are peculiar to them; the limestones contain the usual Brachiopoda and corals which are found in the upper members of the series. Ascending in the series, beds of dark gray limestone, frequently arenaceous, occur, alternating with dark gray, red and green shales and gray sandstones, the shales containing the same fossils as before. These alternations are 300 feet thick, the limestone amounting to about one-third of the whole. Still ascending, there are a series of beds of arenaceous limestone, some of which are burned for lime, amounting to about 100 feet: from these beds 108 species of fossils were collected, of which 96 are common to the upper members of the carboniferous limestone of Ireland. The most numerous are Productæ, Orthis, Atrypa, &c. These limestones are succeeded by beds of dark gray shale, gray and yellowish sandstone, and some thin beds of impure limestone about 360 feet thick; the shales as usual containing fossils, the *Modiola Macadami* (Port.) being abundant, with some fish-scales and teeth, and plants.

On the western shore of Killala Bay, the yellow sandstone of Kilcummin Head is succeeded by beds belonging to the carboniferous slate, or lower limestone shale, which are at once recognized by the absence of sandstone and the abundance of corals, particularly by several varieties of Fenestellæ, which are very rare in the shales beneath: these corals may be considered characteristic of the carboniferous slate. Thus it appears that on the north coast of Mayo there is a thickness of strata amounting to 1400 feet intervening between the bottom of the red sandstone and the carboniferous slate, the whole of which contains fossils, with the exception of the hard beds of red and gray sandstone, which with few exceptions are devoid of organic remains, whether at the base or top of the series. The question then arises, can we separate the lower portion of the section, which assumes a red colour, from the upper, when it is remembered that the gray shales and limestones which alternate with the red sandstones contain more than three-fourths of the same fossils that are found higher up in the carboniferous limestone series?

Mr. Griffith next described the district situated to the north-east of Lough Erne, which contains a great variety of strata belonging to the Carboniferous, the Upper Silurian, and Mica-Slate systems. The succession of the strata as they occur in this interesting district was exhibited in two sections, one of which extended from the mica-slate district of the county of Donegal, north of Pettigoe, across the limestone and sandstone valley of Pettigoe, Kesh and Ederny; it afterwards traverses the brownish-red conglomerate and sandstone district of Lisnarick and Irvinestown, and in continuation the dark gray slate district of Lisbellaw, which contains Silurian fossils; from whence it is continued across the limestone valley of Brookborough, thence over the Slievebeagh mountains, and terminates in the greywacke slate district of the county of Monaghan, thus exhibiting the structure of the country for a length of forty-two miles. The other commenced in the mica-slate of Dooish mountain, county of Tyrone, and extended eastward, traversing the great district of brownish-red sandstone and conglomerate, and in continuation the carboniferous limestone series of the valley of Clogher; then crossing the Slievebeagh mountains, terminates in the greywacke slate at Newbliss in the county of Monaghan.

Commencing at the northern extremity of the most westerly of these sections, that near Pettigoe, we find the mica-slate covered in an unconformable position by a bed of red conglomerate about fifty feet in thickness, which is succeeded by yellow sandstone alternating with dark gray shale, and occasional beds of dolomitic limestone; the shale contains the casts of plants, and also in abundance *Modiola Macadami*; these strata are about 150 feet in thickness: above we have alternations of dark gray shale with occasional beds of gray sandstone, and a few beds of calcareous clay ironstone sixty feet thick. This mass of shale and sandstone is succeeded by a series of beds of blue limestone, occasionally alternating with dark gray shale and yellowish-gray sandstone 300 feet in thickness. It is remarkable that a thin bed of coal half an inch thick is included between two of the limestone beds at the base of this division: the limestone is frequently dolomitic, and, as is usual in such cases, fossils are of rare occurrence. Above we have a succession of beds consisting of alternations of limestone and dolomite about 100 feet in thickness, followed by alternations of dark gray impure limestone and black and gray shale 300 feet thick, on the top of which we have beds of gray siliceous limestone about sixty feet in thickness. These calcareous strata are succeeded by a great accumulation of beds consisting of gray sandstone and shale; in some places the sandstone, and in others the shale predominate, the whole being interspersed with occasional beds of impure limestone, amounting altogether to a thickness of about 700 feet. The shale contains in abundance *Modiola Macadami* and the usual fossils belonging to the shale beds.

These strata are followed by others very similar in character, excepting that the sandstone rather predominates: near the base, in the lands of Formil, close to the village of Kesh, a bed of highly carbonaceous shale with two inches of bituminous coal occurs in the sandstone. The shales produce the same Modiolas, Pectens, &c. as those lower in the series; but on the lands of Drumcurren, on the left bank of the river Banagh, numerous perfect casts of the scales of the *Holoptychius Portlockii*, accompanied by a single specimen of a tooth of the *Chomatodus linearis*; also plants identical with those of Kilcummin Head, particularly the Sphenopteris, and a small-leaved plant, apparently a Fucoid.

Above the fish-scales, and approaching the great or lower limestone, the shales were found to contain Fenestellæ, accompanied by Turbinolia, &c., indicative of the carboniferous slate, but owing to the unusual abundance of sandstone which accompanies the shale, it is impossible in this locality to draw the line of separation between the carboniferous slate or lower limestone shale and the yellow sandstone; the thickness of this upper portion of the series may be about 1200 feet, thus making the whole series, including the yellow sandstone and carboniferous slate, about 2900 feet in thickness. The carboniferous slate is succeeded by the lower limestone, the thickness being about 700 feet, and this again by the calp shale and calp sandstone.

Near Lisnarick, in the line of section, the calp series rests unconformably on brownish-red conglomerate, forming a portion of the great district, chiefly composed of alternations of that rock and brown micaceous shale and sandstone slate, which occupies considerable portions of the counties of Fermanagh and Tyrone, and which in two localities, as at Pomeroy and Lisbellaw, is connected with rocks belonging to the Silurian system.

In the line of section this series occupies a tract of country extending from Lisnarick on the west to Lisbellaw on the east, a distance of fourteen miles. At Lisbellaw the Silurian rocks are suceeeded unconformably by strata belonging to the yellow sandstone series, which is here very imperfectly developed, owing probably to its being cut through by the projection through it of the Silurian and brown sandstone series. The yellow sandstone is followed by the carboniferous slate, and this again by the lower limestone, and in continuation by the calp, and calp sandstone of the Slievebeagh mountains, from beneath which in an eastern direction we find the lower limestone and carboniferous slate, appearing at the surface in the valley of Monaghan, and terminating unconformably on the greywacke slate which bounds that valley to the south-east.

The most important part of this section, as far as the lower members of the carboniferous series are concerned, is that situated to the west of the brownish-red conglomerate district. In it we find the same succession of strata which have already been discovered as occurring on the north coast of Mayo: we have the same alternations of sandstones, shales, and impure limestone at the base, succeeded by shales and sandstones and thin beds of limestone, each part of the series producing the same fossils; the limestone beds, whether arenaceous or argillaceous, containing those which belong to the upper portions of the limestone series; while the shales which lie below, among, and above the arenaceous limestone, contain the same fossils, the most characteristic being *Modiola Macadami*, the most remarkable the scales of the *Holoptychius Portlockii*, and of the plants the Sphenopteris and the smooth-leaved Fucoid; hence no doubt can be entertained of the necessity of including both in one series, the whole being followed by the great or lower limestone.

A remarkable and extensive district of yellow sandstone occupies the whole of the southern shore of Lough Foyle in the county of Londonderry, between the city of Derry and the basaltic headland of Magilligan, from whence it extends southward to Dungiven, and thence by Draperstown to the base of Slieve Gallion mountain in the county of Londonderry. The strata in this district are divisible into three portions. The lowest is characterized by its conglomeritic structure and the absence of shale or calcareous matter. The colour of the base of the rock is usually red. The pebbles, or rolled fragments of the lower beds, consist of mica-slate, similar to the rock on which it rests, and the upper of white quartz, and occasionally of red quartzose sandstone. These strata in the Douglas river, near Draperstown, may amount to a thickness of 600 feet. The second division of the series is distinguished by its containing numerous beds of dark gray shale approaching to black, alternating with gray sandstone and some thin beds of impure limestone: its thickness may be about 500 feet. The upper or third division consists of red sandstones and red conglomerate, brownish-red, and greenish- and yellowish-white shales frequently passing into marl, and containing numerous bands of light gray nodular limestone, and occasionally arenaceous and sometimes conglomeritic limestone, above which is a thick series of beds of dark gray shale, which at Cullion forms the upper portion of the series.

No fossils have been found in the lower division; the second, or black shale division, contains numerous fossils, particularly several varieties of Cythere, *Modiola Macadami, Cypricardiæ, Murchisonia elongata,* and several kinds of fishes, especially Gyracanthus and Holoptychius, several of which have been described by Capt. Portlock, but many have not been noticed by him. The thin limestone bands in the White Water abound with obscure Atrypas, apparently the *Atrypa gregaria,* which also abounds in Ballington, near Ballycastle, in the county of Mayo.

The third, or upper division, which is about 1400 feet thick, contains no fossils; but the gray quartzose and conglomerate limestone which succeeds it contains *Orthis crenistria, O. filiaria, Spirifera bisulcata, S. attenuata, Bellerophon apertus, Lithodendron, Fenestellæ,* and other fossils of the carboniferous limestone, while the shale which succeeds this produces a profusion of similar fossils, together with many others which usually occur in the upper shales of the calp.

This remarkable deposit of sandstones and shales, which occurs in the valley of Ballinascreen, differs in some respects from the districts of yellow sandstone already described, in its containing no thick series of beds of fossiliferous limestone; but the occurrence of certain fossils, as *Modiola Macadami, Holoptychius Portlockii,* and ten or twelve species of Cythere similar to those found elsewhere, prove that they belong to the series of shales which accompany the arenaceous limestone of the north coast of Mayo, and in the district of Pettigoe, north of Lough Erne.

Another locality in which the same fossils occur is the carboniferous valley of Ballinamore in the county of Leitrim, situated between the Cairn Clon Hugh mountains of the county of Longford, and the millstone grit district of Slieveaneerin in the county of Leitrim. The strata of this valley comprehend the entire suite of the Carboniferous Limestone system of Ireland.

Commencing from below, as exhibited in the section of the valley, we have the greywacke slate of Cairn Clon Hugh succeeded unconformably by thin beds of red sandstone conglomerate, followed conformably by yellowish-gray conglomeritic sandstone, on the top of which are beds of impure arenaceous limestone and dark gray shale, with a few thin beds of dark gray sandstone, altogether about seventy feet in thickness. These are followed by 150 feet thick of yellowish-gray quartzose sandstone, succeeded by argillaceous limestone, alternating with thin beds of dark gray shale and gray calcareous sandstone; about 100 feet above which is the carboniferous slate, lower limestone, calp and upper limestone in regular succession, the latter being covered by the millstone grit series of Slieveaneerin mountain.

In the lowest calcareous strata noticed in this section, particularly in the lands of Monaduff in the county of Longford, were discovered numerous species of Cythere; also in abundance *Modiola Macadami,* and several plants, together with fish-spines not described, and beautiful specimens of *Oracanthus Milleri,* perfectly identical with that found in the Bristol limestone, and several specimens of Ctenacanthus. The second limestone above the shale also contains plants, some resembling Lepidodendrons of the coal series, but of a new species. The upper beds of this limestone contain *Orthis crenistria* in great abundance, and other fossils of the limestone series. The carboniferous slate which succeeds these strata contains the Fenestellæ, and the other fossils characteristic of that division of the limestone series, as do also the lower limestone, calp, and upper limestone of Slieveaneerin.

Referring to a small district of red sandstone, gray shale, and yellow and red limestone which occurs at Cultra, on the southern shore of Belfast Lough in the county of Down, Mr. Griffith said the strata of this locality had previously been considered by him and other geologists to belong to the new red sandstone and magnesian limestone group, but from a careful examination he had made of its strata and fossils within the last year, he was now decidedly of opinion that they are coeval with the valley of Ballinascreen. The section of the strata consists first of a base of the well-known greywacke of the county of Down; its strata are succeeded unconformably by red sandstone passing into conglomerate, alternating with red and occasionally reddish-gray shale, and higher in the series we meet thin beds of compact red limestone; next fine-grained red and bright yellow calcareous sandstone, containing some beds of bright yellow, fossiliferous dolomite, containing casts of *Cucullæa complanata, C. unilateralis, C. Hardingii, C. trapezium, Pullastra antiqua,* with Nucula, Cypricardia, and some obscure univalves. These fossils are similar to those of Marwood in North Devon.

The yellow beds appear to be succeeded by dark gray shale, the thickness of which cannot be ascertained, as it extends seaward under low water. This shale contains in abundance the scales of *Holoptychius Portlockii,* two or three varieties of Palæoniscus, with bones, spines, &c. of fishes undetermined, together with fifteen varieties of Cythere, *Modiola Macadami, Cypricardia socialis, Orthoceras regulare,* and other fossil shells which are common in the gray shales, accompanying the arenaceous limestone in the West of Ireland.

The southern portion of the section commences at Castle Espie on the shore of Strangford Lough. Resting unconformably on a greywacke base, we have here the lowest limestone of the carboniferous series: it contains *Actinoceras Simmsii,* which is probably the same as *Orthoceras giganteum* of Sowerby, *Actinoceras pyramidatus, Producta gigantea, P. latissima, Orthis cylindrica, Spirifera imbricata, Athyris glabristria, Syphonophyllia cylindrica, Turbinolia fungites,* &c.; these strata are covered by beds of red sandstone, dipping at a small angle under an arm of Strangford Lough, but succeeded on Scrabo Hill by reddish-gray and light yellowish-gray fine-grained sandstone. The sandstone of the Scrabo quarries is much used for building in the surrounding country. At Scrabo, and to the north and east of it, the rock has the same dip and inclination as at Castle Espie, accumulating to the north till it comes in contact with the greywacke slate of the Ards peninsula. By surveying other points in the range of this rock, Mr. Griffith arrives at the conclusion that the sandstone of Scrabo Hill is above the limestone of Castle Espie, and also that the sandstones and gray shales of Cultra are higher in the series than the same limestone. Castle Espie limestone appeared to represent the impure arenaceous limestone of the north coast of Mayo, and of Pettigoe in Fermanagh, and the gray shales which contain the ichthyolites to correspond with the grey shales of Kilcummin Head in Mayo, of the Bannah River in Fermanagh, of Monaduff in Longford, and of Ballinascreen in Londonderry; and when we consider that these shales are interstratified with calcareous strata which contain numerous fossils belonging to the upper members of the carboniferous limestone of Ireland, we must perforce class the whole series with the carboniferous limestone. Hitherto fossils of the genus Modiola have been considered to belong to the Old Red Sandstone or Devonian system, but as he had discovered these fossils in great abundance as high up as the carboniferous slate, and far above the arenaceous limestone, he should include them among the fossils belonging to the Carboniferous system; and hence, as these fossils have been met with in the red shales which alternate with red and gray sandstones and limestones near the bottom of the series, and among those strata which he had hitherto considered to belong to the upper portion of the Old Red system, he thought he was warranted in including them in the carboniferous series.

From what he had said, the red colour of the sandstone beds can be no longer considered as indicative of age, as he had shown that in several localities the red sandstone and red conglomerate occur above the arenaceous limestone and ichthyolite beds.

In following this view it will be difficult in some localities to determine the line of separation between the red sandstone of the Carboniferous and that belonging to another system which lies below; but in the northern counties a very decided line may be drawn, owing to the unconformability of the two systems.

On the Old Red Sandstone, or Devonian and Silurian Districts of Ireland. *By* Richard Griffith, *F.G.S.*

Mr. Griffith classed these two systems together owing to the difficulty he experienced in some localities in the North of Ireland in separating strata, which from their fossils might be considered to belong to the Silurian system, from those which, from their geological position and lithological character, have been hitherto classed with the Devonian or Old Red Sandstone.

He commenced with those districts hitherto classed and coloured on his Geological Map as Old Red Sandstone.

The most northern of these districts extends from Lough Erne eastwards towards Pomeroy, and occupies a tract about ten miles wide from Omagh to Ballygawley; it comprises about 300 square miles of the country.

This district is bounded on the north by igneous and metamorphic rocks, and on the east, south and west, by strata belonging to the carboniferous limestone of Tyrone and Fermanagh.

He had already mentioned, in his paper on the Carboniferous Series of Ireland, that in our northern counties, where the red or gray sandstones which form the base of the carboniferous series come in contact with the inferior brownish-red sandstone or conglomerate, that the strata in every case show a sedimentary unconformability. The district in question, when viewed from the limestone country on any side, presents a hilly character; this is particularly the case along its south-eastern boundary, where it rises up from the carboniferous valley of Clogher at a steep angle, forming a range of hills which vary in height from 800 to 1000 feet. The strata dip from the valley towards the hills, so that the base of the series appears on the outer edge.

The lower beds in the valley of Clogher, where they are visible at the unconformable contact with the carboniferous sandstone, consist of a vast accumulation of beds of conglomerate alternating with beds of brownish-red micaceous sandstone, and rarely with red shale. The conglomerate is usually composed of imperfectly rounded masses of brown clay porphyry, varying in size from one inch to two feet in diameter, together with rolled masses of very compact greenish sandstone or quartzite, together with a green matter, probably chloritic earth, imbedded in a brown earthy porphyritic cement, composed of a base of brown earthy matter studded with crystals of white felspar more or less perfect.

Near Cecil demesne, four miles north-east of Clogher, this conglomerate, in very thick masses, alternates with a brownish-red, apparently concretionary rock, composed of irregular sphericles of soft earthy matter, with much white mica arranged in laminæ, so as to be only visible when split in the direction of the strike: when examined with a lens, the cross fracture presents a porous structure, and it is remarkable that in no instance were any of the sphericles broken across in fracturing the rock.

No pebbles or fragments of quartz were observed either in the porphyritic conglomerate or in these finer beds, but the latter usually contains fragments of a very fine-grained brown slate, more or less rounded at the edges.

In some localities, where these finer beds are wanting, the dip and strike of the conglomerate can rarely be determined except by observing the parallel position of the smaller flattened porphyritic pebbles, and occasionally the finer sedimentary layers.

On the large scale, therefore, this trappean conglomerate, which in many of its characters resembles the trappean ash beds of Sir H. De la Beche, may be said to be arranged in beds, but on the small it bears a resemblance to compact gravel. In fact, in many cases where it appears at the surface on banks of rivers and streams, it cannot be distinguished from ordinary diluvial gravel except by its superior hardness.

Quartz pebbles very rarely occur in this rock, a circumstance that seems to distinguish these conglomerates from most others.

Ascending in the series, the conglomerate beds gradually diminish in number and thickness, and give place to the finer variety, which now assumes the character of an ordinary reddish-brown sandstone; the mica still prevails, and fragments of fine brown slate are frequently abundant. As the beds accumulate, reddish-brown shale appears alternating with the sandstone; still ascending, the conglomerate disappears, and the shale increases until, in the neighbourhood of Fintona and Dromore, the shale predominates. From the south-east boundary of the district, as far as Dromore, the strata dip north-west, but here is a synclinal axis and the dip is reversed, and consequently in proceeding from that place north-westward we are descending in the series, and approaching Dooish mountain we meet with a porphyritic conglomerate, dipping at a steep angle towards the southward, closely resembling that at the east border of the district already described.

Besides the trappean ash conglomerate, for such he must consider it, the district contains other rocks of an igneous character. Tracts occur composed of a brownish felspathose porphyry, apparently a metamorphic shale, or fine-grained sandstone. The hill called Barrack Hill, south of Pomeroy, is formed of this rock, as is also the hill of Millix near Ballygawly; at this latter place it exhibits every appearance of having been projected through the trappean conglomerate.

Trap dykes also occur in this district, and some of them are remarkably large, and can be traced for many miles along the surface.

Connected with the strata above described and lying beneath them, apparently in a conformable position, there are two small districts composed of gray arenaceous and schistose beds, which contain numerous fossils, many of which are similar to those described by Mr. Murchison in his 'Silurian System.' One of those districts is situated close to Pomeroy in Tyrone, and the other at Lisbellaw in the county Fermanagh.

The composition and the fossils of these districts have been so lately described by Captain Portlock in his 'Geological Memoir of the County of Londonderry and portions of Tyrone and Fermanagh,' that he would not enter upon them further than to state, that the upper portion of the series at Pomeroy and at Lisbellaw contains beds of conglomerate composed of pebbles of quartz, mica-slate, and occasionally green chloritic matter with a quartzose cement. This conglomerate alternates with dark gray shale, and in some localities with red shale and brown sandstone.

The great mass of the reddish-brown sandstone and conglomerate lies conformably above the fossiliferous Silurian slates, and unconformably under the carboniferous rocks, hence arises the probability of the sandstone belonging to the Silurian series.

Mr. Griffith next directed the attention of the Section to another district of reddish-brown sandstone and conglomerate, exactly similar in geological position, in composition and character, to that just described.

This district forms a narrow mountain ridge, known by the name of the Curlew mountains, and extends from Drumshanbo in the county of Leitrim to the north of Boyle, Lough Gara, and Ballaghaderreen, to Mullaghanoe Hill near Swineford in the county of Mayo, forming a chain of hills thirty-two miles in length, and rarely more than three miles in width from north to south; the greatest elevations being the Curlew mountain 863, and Mullaghanoe 775 feet.

The characteristic rock of this district is compact reddish-brown sandstone, alternating with red shale, and including tracts of metamorphic slate passing into semi-porphyry, precisely similar to the Tyrone district; the conglomerates are sometimes trappean, but usually contain quartz pebbles in abundance. In some localities the metamorphic rock is schistose, and passes into compact reddish-brown slate, presenting only imperfect crystals of felspar; in others the line of division between the reddish-brown sandstone and the metamorphic porphyry is quite abrupt, so as to give to the latter the appearance of a protruded mass. A good example of this fact is seen to the north of the demesne of Ballyedmond near Ballaghaderreen, where the metamorphic rock forms a tongue, enveloped by the ordinary reddish-brown sandstone and shale unaltered, or at least very slightly affected at the contact.

In the midst of the metamorphic porphyry in the lands of Egool, about one mile south of the mountain of Mullaghanoe, are found a series of rocks composed of alternations of brownish-red sandstone and shale, greenish-gray quartzite, greenish and bluish clay-slate, and impure gray limestone.

The succession commencing from the north consists of a base of metamorphic porphyry, above which we have—

	Feet.
1. Greenish-gray quartzite, stratification irregular, about	400
2. Gray quartzose conglomerate	150
3. Greenish-gray fossiliferous slate	200
4. Reddish-brown sandstone and shales, about	200
5. Impure limestone, very fossiliferous	60
6. Dark gray slate, fossiliferous	160
7. Alternations of red conglomerate, red sandstone, and red sandstone slate	300
8. Alternations of greenish-gray quartzite, sandstone and slate, about	1000
Total	2470

The fossils found in Egool consist of—

Cephalopoda—*Orthoceras imbricatum, Bellerophon dilatatus.*

Brachiopoda—*Orthis rustica, O. semicircularis, O. radians, O. lata, Atrypa aspera Leptæna depressa.*

Zoophyta—*Stromatopora concentrica, Favosites alveolaris, F. fibrosa, F. spongites, F. polymorpha, Catenipora escharoides, Porites pyriformis, P. patelliformis, Acervularia Baltica, Limaria fruticosa, Turbinolopsis bina.*

The whole number of described species found amounts to twenty-seven, of which nineteen occur in England—three in the Caradoc sandstone, and not above it, and sixteen in the Wenlock rocks, and the shale above them.

It is to be observed, that the whole of the corals are found in an impure limestone, and none above or below it.

Thus it appears that the reddish-brown sandstone district of the Curlew mountains comprehends a series of strata alternating with red sandstone and conglomerate which contains sixteen varieties of fossils common to the Upper Silurian system of Murchison, and three to the Lower.

It appears also that the small schistose districts at the base of the great sandstone at Pomeroy and Lisbellaw already mentioned, also contain numerous fossils belonging to the Silurian system, and many of which are common to the district of the Curlew mountains. These facts merit much consideration. If we class the sandstone and conglomerate with the Old Red system, the fossils which occur in beds interstratified with those rocks must be considered to belong to that system. If this be not admissible, then the sandstone and conglomerate of the Curlew mountains and the Pomeroy district must belong to the Silurian system.

He would not enter into any further detail relative to the reddish-brown sandstone of the North of Ireland, further than to point out another district of reddish-brown sandstone and conglomerate, situated to the north of Castlebar, and extending from Newport to Lough Conn in the county of Mayo, which is similar to the foregoing, and which also lies unconformably beneath the carboniferous limestone at Castlebar; but as yet no fossiliferous beds have been discovered in it.

Mr. Griffith next directed the attention of the Section to a small district situated close to the town of Kildare, in the county of Kildare, in which he had lately discovered Silurian fossils.

This district is about three miles long and one broad, and extends from the Red Hills to Dunmurry Hill. The strata consist of alternations of gray limestone and gray clay-slate, both very fossiliferous. Among the fossils collected, thirty-two were known species; eighteen of which have been described in the 'Silurian System,' all of which occur in the Caradoc sandstone, but five of them are common to the Wenlock and upper rocks.

Mr. Griffith next described another Silurian district, situated at the western extremity of the Peninsula of Dingle, in the county of Kerry. The strata consist of gray slates associated with red and gray quartzites, and occasionally conglomerates. The fossiliferous beds are numerous along the shore at Ferriter's Cove, and also at Doonquin, from whence they extend eastward into the country in the line of the strike.

He also briefly noticed the occurrence of Silurian fossils in the gray slates of the coast of Waterford, particularly at Knockmahon Copper-mines, Ballydowan Bay, and Tramore; and mentioned that this district had not yet been sufficiently examined, and that probably it extended beyond the limits marked out for it on his Geological Map.

He observed, that in colouring the Geological Map, particularly in the south of Ireland, he experienced great difficulty in drawing a line of separation between the Silurian and old red sandstone groups; the series evidently graduated into each other, and where fossils were wanting, lithological character formed his sole guide. He experienced considerable difficulty in determining to which group the chloritic and gray quartzites of the Gap of Dunloe near Killarney, of Macgillacudy's Rocks, Mangerton, and the whole range of mountains extending thence to the eastward should be attached; but finding similar green and gray quartzites associated with the beds in which Silurian fossils occur in the Dingle Peninsula, and also in the county of Waterford, he thought it prudent provisionally to attach them to the Silurian group, but he hoped still to find fossils which would determine the difficulty.

On the occurrence of a Bed of Sand containing recent Marine Shells, on the summit of a Granite Hill, on the coast of the county of Mayo. By Richard Griffith, *F.G.S., &c.*

The peninsula called the Mullet of Erris, is situated to the west of Broad Haven and Blacksod Harbour, on the north-western coast of the county of Mayo. Its length is fifteen miles, breadth on the north five miles, and on the south two miles. The northern portion presents some hills of moderate elevation, the most important being Aughalasheen, which reaches the height of 434 feet. The central part of the peninsula, though not absolutely flat, is low and uninteresting, the principal elevation not exceeding 120 feet, the average varying from twenty to sixty feet above the level of the sea. At the southern extremity, the only striking elevation consists of Termon Hill, whose summit is 342 feet above the level of the sea.

The rocks of which this peninsula is composed consist of quartzite, mica-slate, metamorphic mica-slate, passing into gneiss, hornblende slate and granite. The quartzite occurs at the northern extremity, and forms the conical hill of Aughalasheen. The principal tract of mica-slate is situated to the north of the village of Belmullet, to the south of which it exhibits a highly crystalline and metamorphic structure, and the strata present alternations of gneiss with large crystals of felspar, gneiss passing into hornblende slate, and sometimes porphyry; the beds are not thick, but frequently present a tortuous arrangement. The metamorphic strata extend to the southward from the parallel of Belmullet to the south of Elly Bay, a distance of seven miles, where mica-slate again commences, and continues to the base of Termon Hill, which is composed of highly crystalline gray granite, arranged in very large tabular masses, which affect a nearly horizontal position: some of these masses assume a rhomboidal form, others are slightly wedge-shaped, but neither in the external aspect nor internal structure do they exhibit appearances of a stratiform arrangement; in fact they are precisely similar to the tabular-formed granite of Slieve Donard, and other granite mountains in the county of Down.

On the shore at Portglash, at the north-western base of Termon Hill, there is a very fine junction of the granite with metamorphic mica-slate passing into gneiss. The division of the two rocks at the point of contact is quite clear and well-defined, without the least appearance of gradation or passage of one rock into the other. In some places the two rocks do not adhere, the gneissose rock being slightly distintegrated near the contact, in others angular fragments of the schistose rock are enveloped in the granite. There are only a few small granite veins penetrating the slate, which are composed of felspar, quartz and mica, with interspersed garnets, which are abundant where the veins become narrow near the termination.

To the south of the junction the schistose rock forms a narrow band between the granite and the sea, along the west coast for the distance of a mile and a half. In some parts this metamorphic rock is much more crystalline than in others. Where most crystalline, the rock is composed of felspar in small grains, with much black mica, which is arranged in parallel layers, and the general structure of the rock is stratiform, but the great lines of stratification are nearly obliterated; but this rock, though it assumes a granitiform appearance, bears no resemblance to the true white granite close to it, or to the granite veins by which it is penetrated.

A considerable portion of the surface of the peninsula of the Mullet is covered by a vast accumulation of white siliceous sand, containing a great number of recent marine shells, and on the surface some land shells. The varieties found consist of *Purpura lapillus, Littorina rudis, Patella vulgaris, Cardium edule, Mytilus edulis, Littorina littorea, Ostrea edulis, Pecten varians.*

On the west coast of the centre of the peninsula, particularly to the north and south of Elly Bay, the surface of the country is covered by this sand, which is regularly stratified in thin layers, and which forms considerable hills, varying in height from fifty to eighty feet, the whole being formed of sand, without any admixture of mud.

The marine shells are scattered throughout the mass, but appear to be most abundant near the base.

In those positions where the sand has been blown away so as to form valleys among the sand-hills, the surface is thickly strewed with both marine and land shells, so as to give the appearance of their being intermixed; but this is not really the case, as on carefully examining the sections of the sand-hills no land shells were found, though the marine, particularly the *Patella vulgaris*, were abundant, so that we must consider that the land shells were merely superficial, and that the animals originally inclosed within them lived among the tufts of *Arundo arenaria*, with which the greater part of the surface is covered.

The sand and sand-hills just mentioned are not confined to the low country along the sea shore, for some occur on the sides and within a few feet of the summit of the granite hill of Termon, at the elevation of 320 feet above the level of the sea. This sand, which in some places is more than fifteen feet in thickness, contains in abundance all the marine shells already enumerated, together with land shells at the surface, as in the lower sand-hills near the level of the sea.

These elevated sand-hills also present valleys between them, similar to, though on a smaller scale than those on the lower bed; the surface of the sand, and sometimes the bare granite rock, is covered by marine shells, which show that the wind, which has the power of blowing away the sand, has not been able to remove the shells. Hence we must conclude that the sand and marine shells once formed the bed of the ocean, and that the whole has been elevated to its present position by the protrusion of the granite; and if this be admitted, it becomes evident that the granite has been protruded, or at least elevated, within the period of recent shells.

On some Geological Phænomena in the vicinity of Cork. *By* FRANCIS JENNINGS, *F.G.S., M.R.I.A.*

The author first alluded to the proof of the elevation of strata as evidenced by the beds of *Ostrea edulis*, in some cases plentifully intermixed with *Littorina littorea*. Some of these beds were of considerable extent and depth; in one of them the shells were broken, and appeared as if they had been subjected to the action of waves on the sea-shore, whilst those on another bed were in many cases in pairs, and something resembling the dried animal appeared within.

On many parts of the coasts of the counties of Cork and Waterford there are evident proofs of the land having subsided; peat and bogwood being dug out of the strands at the edge of the water during ebb-tide, and every storm washing large trunks of trees on the beach, which in some places are visible *in situ* below the lowest water of low tides; the oak, hazel, and birch being the most abundant.

The universal opinion of the people on these coasts is, that the sea is advancing; and old accounts of these places confirm this opinion, and render it probable that the land at the present time is subsiding in some of those districts alluded to. The cliffs are formed of clay, large portions of which are constantly detached, and the immense quantities of sea sand removed for agricultural purposes must render more easy the advance of the sea on the level ground bounded by those clay cliffs, the land behind them being in most cases peat bog. The amount of sand removed in a year from Youghal harbour amounts to about 279,000 tons, from Cork harbour to about 400,000 tons, and from Kinsale and Oyster haven 330,000 tons; and this annual drain must effect ere long very important changes, especially where the sand is raised from the beach, as at Youghal. In the other places alluded to it is all dredged from a depth varying from ten to about forty feet, and in many bays which formerly yielded sand in abundance there is now but little if any to be found; which probably may be explained by the quantity taken for agricultural purposes.

Much of this sea sand contains from 60 to 65 per cent. of carbonate of lime, and some of phosphate, principally derived from the shells of the Crustacea; it also contains some animal matter from the living mollusca with which it abounds.

The amount of sand raised must also have an important effect upon commerce, in keeping clear those harbours where sand is thrown in such quantities as to impede the navigation; the sand thus raised by dredging is sold, after a water carriage of six miles, for 6*d*. per ton, a price, when the labour is considered, remarkably low.

On some Beds of Limestone in the Valley of Cork. *By* C. Y. HAINES, *M.D.*

This outlying portion of the carboniferous system is described as consisting of three thin beds of ferruginous limestone, interstratified with carboniferous slate and yellow sandstone, forming part of a series underlying the limestone of the Cork valley: it is situate at Riverstown, and crops out at the summit of an anticlinal elevation; the limestone and slate contain Encrinites, Turbinoliæ, Spirifers, &c. Dr. Haines also exhibited some rare and undescribed fossils from the Cork limestone, and a slab of millstone grit from Kilrush, County Clare, containing some new and extraordinary impressions, apparently of a marine Annelid, slightly resembling a species of Myrianites figured in Mr. Murchison's 'Silurian System,' as occurring in the Cambrian slates.

The "Permian System" as applied to Germany, with collateral observations on similar Deposits in other countries; showing that the Rothe-todte-liegende, Kupfer-schiefer, Zechstein, and the lower portion of the Bunter-sandstein, form one natural group, and constitute the Upper Member of the Palæozoic Rocks. By Roderick Impey Murchison, *Gen. Sec. B.A. and Pres. of the Royal Geogr. Soc.*

When first proposed by Mr. Murchison*, the word Permian was intended to distinguish a natural group of deposits lying between the well-known carboniferous strata beneath and the less perfectly defined trias above it. The author at first suggested that the group (so designated, from the ancient kingdom of Permia which is exclusively occupied by it) should combine those deposits known under the names of Rothe-todte-liegende (lower new red of England), Kupfer-schiefer, and Zechstein, &c. (magnesian limestone, &c.). Subsequently, however, he was disposed to doubt whether it might not be more correct to class the rothe-todte-liegende with the coal-bearing deposits beneath it, than with the zechstein or magnesian limestone above it, in consequence of a belief on the part of some geologists, that the plants of the lower red sandstone which overlie the coal in many parts of England could not be distinguished from those of the coal-measures. Revisiting Hessia, Saxony, Silesia, the Thuringerwald and other parts of Germany, during this spring and summer, Mr. Murchison has obtained what he considers to be satisfactory proofs that the rothe-todte-liegende is part and parcel of the same natural group as the zechstein, and must therefore be considered a member of the Permian system. He has also convinced himself that a reform is called for in defining the lower limits of the "Trias" of foreign geologists; and being confident that his researches, and those of his companions in Russia (M. de Verneuil and Count Keyserling), have afforded a key to the solution of this question, which had not been previously obtained, he takes this occasion of the meeting of the British Association to suggest, that the great deposit hitherto known under the synonymous terms of Bunter-sandstein, Grès bigarré, or new red sandstone, should be divided into two parts, the lower of which ought to be classed with the Permian, and separated from the trias, with which it has been merged.

To prove the first of these positions, or that the rothe-todte-liegende is a part of the Permian group, Mr. Murchison cited the order of succession, and numerous sections in Germany, showing an uninterrupted sequence from the lower red conglomerate sandstone and shale into the overlying zechstein. It was then stated, that this red deposit, so copiously developed in Saxony, was there invariably separated in the clearest manner from the underlying coal-fields with which it is in contact, either by being positively discordant with or transgressive to the edges of such coal beds, or by occupying irregular and eroded depressions upon their surface. These facts have recently induced the Saxon geologists, including Professor Naumann, to disconnect the rothe-todte-liegende and the productive coal-measures, though formerly they were supposed to be connected. On the other hand, the rothe-todte-liegende, or lower new red, passes up into the zechstein. The question then is, can the plants of this lower red rock be distinguished as a whole from those of the subjacent coal-measures—plants being as yet the only organic remains found in these red sandstones?

From his own observations in Saxony, and particularly from an inspection of the fossil plants collected, and in part described, by an active geologist Captain Gutbier of Zwickau, Mr. Murchison believes, that such a separation is indicated in nature. For, although the general character of the flora of the one deposit agrees with that of the other, it is a remarkable fact, that in the tracts around Zwickau, which are

* See Letter from Moscow, September 1841, Phil. Mag. vol. xix. p. 419.

marvellously rich in coal plants, certain striking forms are found in the rothe-todte-liegende which have never been detected in the subjacent coal strata. Among these are forms of Neuropteris closely approaching to, if not identical with, species which occur in the Permian rocks, and with this similarity there is no trace of the common plants of the underlying coal (*Stigmaria ficoides*, &c.). These plants being imbedded in a whitish or cream-coloured, finely levigated claystone, and their leaves being brought into beautiful relief by being as green as if they had been successfully dried in a herbarium, form admirable subjects for the most precise distinctions of the fossil botanist, and, through the kindness of his Saxon friends, Mr. Murchison hopes to be able to lay some examples of them before the Geological Society of London.

In Silesia (at Ruppersdorf, and other localities west of Waldenburg, between Breslau and Glatz) there is a fine development of strata from the base of the rothe-todte-liegende, where that deposit equally overlies a productive coal-field, *there based upon true mountain limestone*, and passes up into other red sandstones and shales which have a marked aspect, from being interlaced with bands of black, bituminous, thin, flaggy limestone. Though doubts had been entertained as to the age of this limestone, Mr. Murchison does not hesitate to consider it the equivalent of the zechstein, and the whole red group of which it forms a member, as the Permian system; for besides its very clear position, this calcareous flagstone contains plants and fishes similar to those of the Permian rocks of Russia. Among the former the *Neuropteris conferta*, nov. sp., of the distinguished botanist Göppert, has been identified with one of the most common forms brought from Russia. The most abundant fish is the *Palæoniscus Vratislabiensis*, Ag.*

On this occasion Mr. Murchison passed rapidly over the zoological proofs that the zechstein and kupfer-schiefer of Germany are the equivalents of the calcareous beds of the Permian system of Russia, as these have been spoken of in memoirs read before the Geological Society, and will shortly appear at length in a work upon the geology of Russia. On this point, however, he begged to take the opportunity of publicly stating, that his opinion was now perfectly in harmony with that of his distinguished friend Professor Phillips, viz. that the fauna of the zechstein, or magnesian limestone, has to so great an extent the same general zoological type as the carboniferous limestone, that it must also *form a part of the palæozoic series*. Mr. Murchison formerly withheld his assent to this opinion because the rock in question contained Saurians,—animals unknown in the lower palæozoic deposits—and also because the zechstein or magnesian limestone seemed to him to be more naturally connected with the strata overlying it, than with the underlying carboniferous system. On the latter point Mr. Murchison called the attention of the Section to the fact, that the examination of Russia had established what was previously unknown, viz. that considerable masses of *red sandstone, marls and conglomerate overlying bands of limestone with unequivocal zechstein or magnesian fossils, contained, nevertheless, the same group of plants and fishes as was associated with the underlying beds, and also peculiar Thecodont Saurians*, which Professor Owen has pronounced to be similar to those of our magnesian limestone, or to the *Protorosaurus* of Germany. What then was to be done with this great overlying mass, occupying exactly the same place in the series, and often closely resembling, in mineral character, the lower half of the bunter-sandstein? The answer is, that as the old line of demarcation, which included all this mass in the trias, was founded solely on lithological aspect, so must it bend to the new evidences, be grouped with the zechstein, and under the name of Permian, be considered as the upper member of the palæozoic series.

Mr. Murchison postponed his announcement of this view until he had ascertained, whether the natural sections in any part of Germany afforded data to contradict it. But his recent excursion enables him to say, that neither in Hessia, nor in Saxony, nor in the Thuringerwald, the countries where the zechstein and kupfer-schiefer are most fully developed, do the red rocks which form their roof contain any animal remains whatever, and all the German professors to whom he has referred are ignorant of such. The truth is, that the upper mass *only* of the bunter-sandstein is that which contains remains of animals and plants analogous to those of the muschelkalk which rests upon it. Such beds, for example, are those of Soulz-les-bains, near Strasbourg, and of Buberhausen, near Deux-ponts; whilst the upper

* In his 'Poissons Fossiles' M. Agassiz has been misinformed, when he terms this deposit carboniferous.

red sandstone of the Vosges, from whence MM. Mongeot and Schimper have described their flora of the Grès bigarré (quite distinct from the "Grès de Vosges," which is probably Permian), occurs in a region where no zechstein exists, and where, therefore, the lower limit of the trias cannot be neatly defined. Again, the beds of sandstone with impressions of the feet of Cheirotherium are all of them (as far as evidences can be obtained) at very little depth beneath the muschelkalk, and may therefore, like the strata of Soulz-les-bains, be most naturally linked on to that deposit. Descend, however, from that horizon through the vast underlying masses which separate it from the zechstein (by far the greater portion of the so-called bunter-sandstein), and no animal organic remains have been found with which the author is acquainted, and hence Mr. Murchison contends, that rocks perfectly representing such lower portion of the bunter-sandstein having been found in Russia to contain the same group of fossils as the other and lower strata of the Permian rocks, must henceforth be separated from the trias and secondary rocks, and grouped with the palæozoic strata.

In support of this view Mr. Murchison read an extract of a letter from Professor Naumann of Leipsig, in reply to his proposed classification, which admits, that there is no evidence in Germany to set against such an arrangement.

In the course of his illustration of this subject Mr. Murchison gave a brief account of other natural sections in Western Germany (as at Baden and Heidelberg), where great masses of the rothe-todte-liegende, resting upon and made up of the primary and crystalline rocks of the Black Forest, were seen to pass up into the lower masses of the bunter-sandstein, usually without any dividing course of zechstein, though at Heidelberg that rock, as on the frontiers of France, is supposed to be represented by a thin band of dolomite.

With regard to the plants of the Permian system brought from Russia, it appears, from the last opinions of M. Adolphe Brongniart, to whom they had been referred, that though they have a peculiar character, they are, for the most part, closely allied to carboniferous forms,—a fact, it is to be observed, which is not only quite in unison with what has been stated in this memoir respecting the plants of the rothe-todte-liegende of Saxony, but is also in complete harmony with the conclusions derived from a study of the *Producti, Aviculæ, Corals* and *Ichthyolites,* all of which are linked on to their congeners of the carboniferous fauna. Mr. Murchison begged the Section to remember, that the Russian plants having this decided *palæozoic* cast, and associated with Palæothrissi and Protosaurians, occur chiefly in bands of marl, conglomerate, &c., *overlying the limestones with typical zechstein fossils*; and this, he observed, was not merely true in a small district, but over an enormous area, in which the strata had never been disturbed by any protrusion of rocks of igneous origin, and in which they were therefore very much in their pristine condition.

In conclusion, Mr. Murchison offered a few remarks on the extent to which the beds of this portion of the British series described by Professor Sedgwick and other authors, might be considered to range under the synonym of Permian*. Speaking in a practical point of view, as respected geological mapping he observed, that by grouping the lower new red with the magnesian limestone, a well-defined breadth of formation was obtained to separate many coal-fields from the younger deposits of red sandstone and marl by which they are flanked; and as the magnesian limestone does not, in many instances, appear in the form of a distinct calcareous deposit, but only as a partial conglomerate, so was it the more desirable to give a certain latitude to this group, and not define it too narrowly by mere mineral characters. Thus considered, Mr. Murchison believed that the Permian system had a real existence even in Ireland; for although true magnesian limestone was unknown in that country, yet, to him it appeared highly probable that the red sandstone loaded with fishes (*Palæoniscus catopterus,* Ag.), at Rhone Hill, near Dungannon, and which he had formerly described as immediately surmounting carboniferous tracts, was in fact a true portion of the Permian rocks, and not of the new red sandstone, as he had supposed.

* Since this memoir was read, Mr. Murchison has practically applied the term Permian, in a new small general Geological Map of England, published under the auspices of the Society for the Diffusion of Useful Knowledge. With his associates, M. de Verneuil and Count Keyserling, he has also prepared a tabular view of the Permian fauna, which consists of nearly 170 species. This will appear in the work entitled 'Russia and the Ural Mountains.'

On the important additions recently made to the Fossil Contents of the Tertiary and Alluvial Basin of the Middle Rhine. By RODERICK IMPEY MURCHISON, *Gen. Sec. B.A. and Pres. of the Royal Geogr. Soc.*

After a sketch of the geographical limits and geological relations of the tertiary deposits which occupy the valley of the rivers Rhine and Mayn around the towns of Mayence, Frankfort and Darmstadt, and a brief allusion to the descriptions of this tract by M. Klipstein and Mr. Lyell, Mr. Murchison gave an account of the recent discoveries of three German naturalists, who have been making such additions to the hitherto known fauna of this basin, as involve considerable modification of former opinions respecting the period of its accumulation. In speaking of M. H. von Meyer's unabated exertions, it was announced that he had prepared drawings of various fossil vertebrata in Germany, sufficient to fill upwards of 300 folio plates, with long and elaborate descriptions of the same. To obtain some acquaintance with these important results, Mr. Murchison begged his countrymen to consult the valuable periodical of Leonhardt and Bronn, too little read, he regretted to say, in the British Isles. Of the animals in the tertiary basin under consideration, M. H. von Meyer has catalogued and prepared for publication—mammifera 68 species, including a new genus, Acanthodon; reptiles 30; birds 13; frogs 8. These creatures are nearly all of undescribed forms, generally of small and sometimes of very minute dimensions—one of the birds being less than the most diminutive existing humming-bird, and therefore the very antipode of the great Dinornis of Owen*.

M. Kaup of Darmstadt, so well known as the discoverer of the Deinotherium and numerous other vertebrata in the deposits around that city, has made some very curious additions to his list, most of which are appearing, as fast as his limited means will permit, in the large and splendid work which he publishes in folio fasciculi—a work which Mr. Murchison lamented had not met with sufficient encouragement to repay the devotion and outlay of the author.

Among the new animals, the *Chalicotherium Goldfussii* was instanced as a genus approaching on the one hand to Anoplotherium, and on the other to Lophiodon; as also the Hippotherium or extinct fossil Horse, &c. &c.

In examining the remains of Rhinoceros, Stag and Tapir, sometimes very perfect, which occur in this deposit, M. Kaup has convinced himself, that they have a close affinity to the types of the Indian and Sumatran Archipelago, and are entirely distinct from all known European mammalia. M. Kaup has also collected a very perfect series of teeth of Mastodons, at different ages of growth, which completely support and confirm the views of Prof. Owen, in proving that the Tetracaulodon, Missourium, &c. of American authors are true Mastodons.

Of the Invertebrata of this tertiary basin, M. Alexander Braun of Karlsruhe gave an account at a late meeting of the German naturalists held at Mayence; but as his memoir has not yet been published, and the author communicated some results to Mr. Murchison, the latter deems it important that geologists should be made generally acquainted with them through the volumes of the British Association. They consist of

Marine contents.

Radiaria....	18	Corals	5
		Foraminifers	12
		Echinoderms	1
Mollusca ...	303	Brachiopods	1
		Acephala	87
		Gasteropods	215
Articulata...	16	Crustaceans	9
		Insects	2
		Vermes or Serpula	5
		Total	337

Terrestrial and Freshwater.

Terrestrial shells	75
Freshwater shells	28
Total	103

of which 10 species only are identical with living forms.

General total 450

Among the numerous shells (and M. A. Braun has in many cases compared hundreds of individuals of each species) there are some which approach closely in form

* See M. von Meyer's letters to Professor Bronn of Heidelberg.

to the remains of the calcaire grossier of Paris; and on the whole, judging also from the ancient appearance of the terrestrial fauna, he is disposed to consider this basin of an early tertiary age. M. Herman von Meyer, drawing his conclusions from the vertebrata (the numerous fishes have not yet however been described), refers the deposit to the age of the molasse and gypsum beds of Paris. The latter idea seems to be strongly sustained by the existence of the Anthracotherium, and of an animal between the Anoplotherium and Palæotherium of the Paris basin.

However much surprise may be excited by the announcement, that the accumulations containing the gigantic Deinotherium form the uppermost part of the Eocene group of Lyell, Mr. Murchison considers the inference to be strengthened by the fact, that these beds rest upon the oldest brown coal and sand of Northern Germany, which near Mecklenburg has been found to contain concretions charged with marine remains, which, according to Count Münster and M. von Buch, belong to the calcaire grossier, or London clay. Mr. Murchison expressed therefore his belief, that the great mass of the tertiary basin of the Rhine would be found to be of the same age as the gypsum beds of Montmartre, or of the Ryde and Binsted strata of the Isle of Wight.

Ancient Alluvia.—This basin is surmounted in ascending order by—1st, coarse gravel, the materials of which have been derived from the adjacent mountains, and this by sand and löss. In the two latter, and in certain tufaceous beds, M. A. Braun and Professor Walchner of Karlsruhe have collected 96 species of shells, 56 of which are terrestrial and 40 fluviatile: of these 7 belong distinctly to species now living, and 9 others very closely approach to, or are varieties of, other living forms. The most abundant forms in the löss are with one exception *very rare* in a living state in the *adjacent cultivated tracts,* and the *common species of such districts are of unfrequent occurrence in the löss.*

With these shells are associated the remains of Mammoth, *Rhinoceros tichorhinus,* and other extinct mammals, the bones of which have evidently undergone very little rolling or destruction; it being not uncommon (as at the mouth of the valley of Baden-Baden) to detect most of the bones of an entire animal near each other.

From the composition of the drift and löss of the valley of the Rhine, and from the state of preservation both of the bones, and of the delicate land and fluviatile shells with which they are associated, Mr. Murchison infers, that in this region, as in the valleys of the Vistula in Poland, and enormous tracts throughout Russia and upon the Siberian flanks of the Ural, the superficial deposits containing these remains have been formed by comparatively tranquil operations, and that the great Mammalia inhabited tracts immediately adjacent to the spots where they are now entombed.

On the Fossils of Polperro in Cornwall. By C. W. Peach.

Some time ago the author received from the Messrs. Couch, surgeons of Polperro, in a letter, two or three small portions of what they considered *coral,* but which Mr. Peach regarded as bone, and *probably fish-bone.*

On the 20th of June last the author found that the fossils in question *formed a large and extensive fish-bone bed,* east and west of Polperro, containing immense quantities of portions of the *Cephalaspis* and *Onchus* of the Old Red Sandstone; also a few other indistinct and ill-defined shells, with portions of the *skin or shagreen of Sphagodus,* of the Upper Ludlow rock, all described in Mr. Murchison's 'Silurian Remains,' with other fragments not mentioned. [Specimens were exhibited from that spot.] They are generally on the under side of the rocks. These are the rocks described in the fifth volume of the 'Geological Transactions,' with "the transverse fracture," which latter circumstance renders it a difficult matter to get out the specimens perfect.

In Giggan Cove, Polperro, there is a large run of limestone, in which Goniatites, &c. are found: it runs along the coast east, and may be traced over Talland sand, to the rocks opposite the "ore stone."

Mr. Peach has found a few and indistinct specimens of fish-bones from the Gribbon along the coast to Mellendreth, two miles east of Looe. The Fowey fish rocks have the "transverse fracture."

The author is engaged in making out a list of the organic remains of Cornwall, which he has found, and are now in his possession.

The author has found a conglomerate in Gorran, in which are large *rolled* masses of limestone inclosing Orthoceratites, Crinoidea and corals, as well as detached corals in the softer parts.

A large specimen was exhibited from the quartz rock of Great Peraver Goran. It is rather abundant there, and covers the sides of some of the blocks four or five feet over: some of the tubes are more than a foot in depth: it appears to be very much like the *Sabellaria alveolata* (recent) in its habit. The upper part of the tubes is funnel-shaped and filled with clay-slate: it is also found *sparingly* in the quartz rock of Caerhayes and Gerrans Bay. Generally they are much distorted.

On the Granite and other Volcanic Rocks of Lundy Island. By the Rev. D. Williams, *F.G.S.*

Mr. Williams described this island as a mass of gray granite, three miles long by about half a mile wide, flanked at its south-east angle by slate rocks, which, beyond the immediate influence of the granite, had an east and west strike, and extended for about half a mile. The circumstances attending the granite were altogether unlike those of any granite mass of Devon or Cornwall. The usually abundant evidences of the processes by which the bounding rocks had been reduced and converted into granite in the vast volcanic laboratories, were all absent. He could not discover a vestige of a granite vein, nor could he observe anywhere a trace of gneiss, mica, or chiastolite slate. In Devon and Cornwall he had often observed that the mineral characters of granite, especially in the veins, varied with the lithological constitution of the sedimentary or other rocks, out of which it had been derived, and with which it was so intimately associated. Besides, the incorporation, the welding, as it were, of the granite in veins with the sedimentary rock, was commonly so perfect that it was altogether impossible to separate them. Now at Lundy Island, although he had repeatedly tried at several visits, he never had succeeded in detaching a specimen of slate united with either the granite, trap, or porphyry, though it was considerably indurated and altered by them, and otherwise in precisely the same condition as the slates in Cornwall. He proposed, in reference to the agency of heat on rocks contiguous to igneous masses, to distinguish between *active* and *inert* heat—the former exerted in reducing the minerals to fluids, the latter simply indurating and otherwise partially altering them. The junctions of the slate and granite at Lundy, which were very clearly exposed on the north-east and the south-west, evidenced nothing more than the operation of inert heat: the granite there was manifestly older than the slates, the slates were older than the traps, and the traps which traversed slate and granite were older than the porphyries, which cut off and shifted the traps.

On the Geology of Corfu. By Captain Portlock.

Extract from a letter to Professor Phillips, dated July 9, 1843:—"The secondary limestone here is remarkable: some of it has strongly the aspect of our Irish hardened chalk, and abounds in flints; but other portions resemble some of the varieties of Irish mountain limestone. Fossils are not abundant; but I have obtained two species of Terebratula from the little fortified island of Ordo, close to us, and they appear to resemble cretaceous species,—certainly not mountain limestone,—though Dr. Davy in his description of these islands seems to consider it the latter. By the autumn I hope to settle this question completely, which will decide the age also of a remarkable conglomerate, containing pebbles of the limestone and flint, and probably tertiary, though called secondary by Dr. Davy."

On the Phænomena and Theory of Earthquakes, and the explanation they afford of certain facts in Geological Dynamics. By H. D. Rogers, *Professor of Geology in the University of Pennsylvania, and* W. B. Rogers, *Professor of Natural Philosophy in the University of Virginia.*

This communication was prefaced by a recapitulation by Mr. Lyell of Messrs. Rogers's observations on the structure of the Appalachian chain of mountains [See

Report for 1842]. The authors first proceed to examine the *phænomena attending earthquakes,* commencing with the following propositions:—1. Earthquakes consist essentially of a wave-like motion of the whole solid ground; 2. the earthquake undulation is not simultaneous throughout the whole area agitated, but is *progressive,* and propagated with enormous velocity; 3. the undulation is transmitted sometimes in the manner of an elongated, curved, or nearly straight belt, moving parallel to itself, and sometimes in the manner of a dilating elliptic or circular zone. The authors then describe earthquake phænomena as divisible into such as are of invariable occurrence, and therefore characteristic, and such as are only occasionally witnessed. The *characteristic phænomena* consist, as announced by the Rev. John Mitchell of Cambridge, in the Phil. Trans. for 1760, of a peculiarly rapid *undulation,* or wave-like motion of the ground, and a sharp vibratory jar, or *tremor*; the undulation generally extending further from the source of the earthquake than the tremor. The *occasional phænomena,* observable only when the earthquake is violent, are a deep rumbling and grating noise, an alternate opening and closing of parallel fissures, and the escape of steam and sulphureous and other vapours, and hot water, from those fissures. In confirmation of these observations, the authors cite the earthquake of Conception, in 1835, described by Captain Fitzroy, and that which visited the island of Hayti in May 1842. As examples of the second proposition, they mention the earthquake of Lisbon, and two others which have occurred during the present year. The first of these took place on the 4th of January, and was felt along the valley of the Mississippi, from the military posts on the frontier west of that river, to the coast of Georgia, and from 31° N. lat. to Iowa, a distance of about 800 miles in each direction; it occurred about 9 P.M., and was sufficiently violent to excite some alarm; throughout the region agitated the motion was both undulating and vibratory. From a comparison of the dates of the shock at twenty-seven different localities, it appears to have been simultaneous along a certain line, stretching in a N.N.E. direction from the western margin of Alabama to Cincinnati, a length of more than 500 miles; it was also synchronous along other lines parallel to this; places to the westward experienced the shock earlier than the other localities, the intervals being in proportion to the distance. From these facts the authors infer "*that the area agitated at a given instant was linear,* and *that the earthquakes moved from W.N.W. to E.S.E. in the manner of an advancing wave.*" The velocity with which the shock was propagated appears to have exceeded thirty miles per minute. The second, or *Guadaloupe earthquake,* was felt along the Windward Islands, at Demerara, and Guiana, Bermuda, and most of the principal cities of the Atlantic seaboard of the United States, from Savannah to New York. Its range, in latitude, amounted to 35°, and in longitude to 23°: the longest diameter of this elliptical area extending from Demerara to New York, was about 2300 geographical miles; and its breadth, from Bermuda to Savannah, 770 miles. The principal intensity of the disturbance was confined to a nearly north and south line, or belt, embracing St.Vincent's, St. Lucia, Martinique, Dominica, Guadaloupe, and Antigua; and thence prolonged to the continent of South America, and to Bermuda. Along this curved axis the shock was simultaneous; and from a comparison of observations made at other stations, it appears to have been propagated eastward and westward at the rate of twenty-seven miles per minute.

In the second part of their communication the authors propose a *theory of the origin and movement of earthquakes,* as applied by them in explanation of the structure of the Appalachian Mountains. According to this theory, the wave-like motion of the earth's surface during an earthquake is of the nature of an "actual billowy pulsation in the molten matter," upon which they suppose the crust of the earth floats, "engendered by a linear or focal disruption and immediate collapse of the crust, accompanied by the explosive escape of highly elastic vapour." The progressive waves of oscillation thus developed on each side of the axis of disturbance, would move off in parallel order, and form dilating elliptic zones. Supposing the earth's crust to be ruptured only at a focal point, as in the orifice of a *volcano,* the receding pulsations would be approximately *circular*; whereas, if the line of fracture were greatly elongated, and the pulsations observed but on one side, the advancing belt of waves would appear straight.

The sea-waves caused by earthquakes are described as broad undulations of the water, moving in the same direction with the pulsation of the crust beneath, at the rate of three and a half miles per minute in the case of the New England earthquake of 1756; and at the rate of five miles per minute during the great Lisbon earthquake, the waves succeeding each other at regular intervals of five minutes. Assuming these sea-waves to correspond with the undulations beneath, the authors calculate the *breadth of the crust-waves* in the Lisbon earthquake at twenty-five miles; and in the earthquake of Conception, where the undulations averaged four per minute, and travelled forward at the rate of forty-two miles in the same time, each wave possessed a breadth of at least ten geographical miles. *The tremor attending earthquakes* is considered as the *effect* of the crushing of the strata during, and caused by, the undulations, rather than as the result of waves of vibration, which would be dispersed and destroyed by the broken condition of the materials and their heterogeneous composition.

Application of the theory of earthquakes.—From these considerations the authors infer, that when earthquakes produce any *permanent* elevation or depression of the land, the tracts so affected will generally have the shape of elongated parallel belts, as exemplified in the Ullah Bund in the Delta of the Indus, the elevation of the coast of Chili, and the local arching of the surface across the bed of a river in Chili, mentioned by Darwin. Referring to their memoir on the Appalachian chain, the authors contend that the structure of those mountains (and, by analogy, those of other countries) implies the operation of far greater and more sudden forces than the gentle secular changes observed in modern times; and they consider it impossible to avoid the conclusion, that all the more extensive revolutions of the earth's crust have involved, to a greater or less extent, the *agency of vast earthquake waves.* To the action of these waves, in different geological epochs, they attribute the formation of the vast masses of conglomerate and detrital deposits distributed in the various groups of strata; also the transport of the great northern drift, and the polished and furrowed surfaces of rocks both in Europe and New England.

An Account of the late Earthquake at the Islands of Antigua and Guadaloupe, on the 8th of February 1843. By the Hon. Capt. Carnegie.

The earthquake is described by the author of the communication as having been felt, generally, among the Leeward Islands, but more particularly at Antigua and Guadaloupe. At both these islands the shock took place at twenty minutes before eleven o'clock, A.M., and it does not appear to have been preceded by any of the usual signs of earthquake; the weather was clear and fine, the sea-breeze blowing as usual, and the inhabitants engaged in their daily avocations. At Antigua the earth heaved and undulated suddenly; the hills oscillated, and huge masses of rock were detached from their summits and precipitated into the valleys; large fissures opened in the ground and closed immediately. The water in the harbour whirled round and round, enveloping the islands in a cloud of dust, which shut them from view, and in the space of two minutes and a half all Antigua was laid in ruins. In this island only eight persons lost their lives, owing to the black population being employed, as usual, among the canes, but the loss of property was immense. At Point-à-Pitre, in the island of Guadaloupe, the effects were much more fearful. In magnitude, this was the second town in the West India islands; it was situated upon a piece of low ground, surrounded on three sides by the sea, and entirely built of stone to avoid the effect of hurricanes. At the time of the earthquake, most of the inhabitants appear to have been at their late breakfast, in consequence of which 4000 perished among the falling houses or in the fire which broke out immediately after; the destruction of the whole town was so complete, as to present, after the earthquake, the appearance of a vast stone quarry. The landslips were very numerous, and all the springs in the vicinity of Point-à-Pitre were instantly dried up. The shock was felt slightly as far north as Washington and Bermuda, and southward to Demerara, travelling in a N.N.E. and S.S.E. direction; several slight shocks were subsequently felt at different periods.

On the apparent fall or diminution of Water in the Baltic, and elevation of the Scandinavian Coast. By Major N. L. Beamish, *F.R.S.*

During a journey to Stockholm in the early part of the present summer, the author had occasion to see and hear much respecting the diminution of water in the Baltic, a practical and personal evidence of which he experienced in the harbour of Travemunde, on the 4th of May, by the sudden fall of water at the port, which took place very rapidly and to a great extent. The steamer, which ought to have left Travemund on the 18th, was detained by this cause until the 21st. It is well known, that although without tide, the Baltic is subject to periodical variations of depth, but the water has fallen during the present summer to a degree far below these ordinary variations: and the fact was considered so remarkable, as to be thought worthy of being brought before the notice of the Swedish Academy of Sciences, by Baron Berzelius, in July last. This fall or diminution of water was already perceptible in the summer of 1842, since which the Baltic has never returned to its average mean height; but, on the contrary, has diminished, and there seems now no probability that the former level, or the height of 1841, will be again attained. Meantime, no perceptible change has taken place in the waters of the North Sea, and the unscientific observer asks, what has become of the waters of the Baltic? The answer is probably to be found in a simultaneous phænomenon apparent on the Swedish coast, the gradual elevation of which has been satisfactorily proved by the personal observation of Mr. Lyell. Recent observation, however, would seem to show, that this elevation does not proceed at any regular or fixed rate, but, if he might use the expression, *fitfully*, at uncertain periods, and at a rate far greater than was at first supposed. At the same meeting, when Baron Berzelius drew the attention of the Swedish Academy to the diminution of water in the Baltic, a communication was made from an officer who had been employed on the south-west coast of Sweden, in the Skärgard of Bohuslän, north of Gottenburg, giving evidence of the recent elevation of that part of the coast, and stating, that during the present summer fishermen had pointed out to him, near the Maloström, at Oroust, *shoals* which had never before been visible. The elevation of the Swedish coast forms a striking contrast with the unchanged position of the contiguous coast of Norway, which, as far as observation has been hitherto extended, has suffered no change within the period of history, although marine deposits, found upon the Norwegian hills, at very considerable elevations above the level of the sea, prove that those parts were formerly submerged. More accurate information, however, will, before long, be obtained on this interesting point, as a commission has been appointed by the Norwegian government to investigate the subject, and marks have been set up on the coast which will, in a few years, afford the desired information. Meantime, the Scandinavian peninsula presents an extraordinary phænomenon; the western, or Norwegian side, remaining stationary, while the south and east, or Swedish sides, are rising, and that, as the author had endeavoured to show, at no inconsiderable rate.

On certain Movements in the Parts of Stratified Rocks. *By* Prof. J. Phillips, *F.R.S.*

The author stated that for many years the attention of geologists had been called in a very essential degree to the internal structure of rocks; but notwithstanding the advances made by Prof. Sedgwick and Mr. Hopkins, there were points still remaining to be investigated, before mathematicians could explain the forces by which these phænomena had been produced; because any such explanation must be based upon data afforded by the actual constitution of the rocks themselves. Twenty years since he had observed such remarkable symmetry in the crystalline forms of prismatic masses of slate in Westmoreland, that he had measured their planes, and satisfied himself that they were not of the nature of ordinary crystallization, and that the term, crystalline structure, as usually applied to them, was by no means legitimate. In order to understand the nature of the mechanical forces which have produced the cleavage, it is important to study it in its relation to every form of strata. Contortions which do not affect the cleavage planes, were evidently formed before them; the joints and fissures which interrupt the cleavage but do not disarrange it, were probably posterior, like many of the faults which interrupt the strata and cut off the cleavage. When layers of concretionary ironstone occur in slaty rocks, the cleavage planes are arrested and "troubled" in their passage through them, from which it appears that the nodules had become solid previously to the strata being divided by the planes of cleavage. Several attempts had been made to imitate cleavage structure. Mr. Fox of Cornwall, had caused electric currents to pass through moistened clay, and had thus produced fissures parallel to the bounding surfaces of the mass, and this illustration Mr. Phillips considered very important, but incomplete. The cleavage planes of the slate-rocks of Wales were, he stated, always parallel to the main direction of the great anticlinal axes, but were not affected by the small undulations and contortions of those lines. In North Wales they maintained the same direction for fifty miles, not varying more than two or three degrees, which might be owing to local causes, such as the movement of masses by gravity at a period subsequent to the formation of the cleavage. In making observations upon the cleavage of rocks, care must be exercised not to confound with these phænomena the marks produced by the mechanical movement of one mass of rock upon another. The layers of shells in slaty rocks were generally distinctly marked by ferruginous lines, caused by their decomposition, and the form of their outlines was often remarkably changed. The Leptænæ in North Devon occasionally assumed the form of Nuculæ, and the Spirifers were crumpled up, or else extremely attenuated. The Trilobites of the Llandeilo flags were found in three distinct forms, arising from the distortion taking place in a longitudinal, transverse, or oblique direction; this seemed to be the result of a "creeping" movement of the particles of the rock along the planes of cleavage, the effect of which was to roll them forward, in a direction always uniform, over the same tract of country: the movement does not seem to have affected the hard shells, but only those which were thin, as also the Algæ and Trilobites: the latter are covered with little folds, parallel to the wave of motion. In these distorted fossils the amount of movement might be estimated; as, in the space occupied by a trilobite, it amounts to a quarter or even half an inch. Mr. Phillips had selected these facts, bearing the aspect of real and general laws of structure in rocks, from a series of classed phænomena on the subject, because he regarded them as positive steps towards a mechanical theory of the series of changes by which the structural characters and accidents of position were to be determined.

Notice of the Ordnance Geological Museum. By Prof. J. Phillips, *F.R.S.*

The Ordnance Geological Survey, now under the direction of Sir Henry De la Beche, has for its object two purposes, both bearing on geological science. The first of these is to procure an accurate delineation of the boundaries of all the strata; not laid down conjecturally, but from actual observation and exact measurement. For this purpose there is attached to the Trigonometrical Survey a staff of active geologists, who walk over the boundary lines and draw sections, in which every part is measured and laid down on a scale true to nature. The practice of making the vertical scale of sections greater than the horizontal had led to much mischief and many mistakes, especially in mining operations, and in working for coal. The second object was to form a collection of the fossils of every stratum in every favourable locality, with the view to ascertain the law of geographical distribution of species, and their geological distribution in successive strata. It was usual for geologists to collect only fine and beautiful specimens; but this method would never enable them to trace the exact areas of distribution of organic life in former epochs. In connexion with this system of collecting organic remains, a method of drawing them had been proposed: each species, as soon as sufficient information could be procured, was to be drawn by good artists, with magnified views of minute structure; and these were to be engraved on steel, a separate plate being given to each species, and published at so low a price as to place them within the reach of all persons interested in the science. Mr. Phillips invited collectors of fossils to give their aid in forwarding this work, by lending specimens of rare or new fossils, and announced that in such cases electrotype impressions would (if approved) be taken of them, so as to supply museums and collectors with correct representations of unique or valuable fossils. In conclusion, Mr. Phillips stated that the Ordnance Museum would be eventually opened to the public as freely as any institution of the same nature.

Letter from the Astronomer Royal to the Earl of Rosse. *Communicated by the* Earl of Rosse.

Birr Castle, 10th August, 1843.

My dear Lord,—It is probable that the geological circumstance to which I am about to call your attention has already been noticed by the geologists of Ireland; but if it has not, perhaps you may consider it sufficiently important to be made the subject of a communication to the Geological Section of the meeting shortly to assemble under your lordship's presidency at Cork.

The circumstance to which I allude is, the existence of numerous traces of glacier-friction on the north-west side of Bantry Bay.

My own examination of that country has been confined to the two lines of road, one from Glengariff to Ardagh and into the bosom of Hungry Hill, the other the road from Glengariff to the pass leading to Kenmare. Near to both of these roads, marks of the glaciers may be seen, but they are more numerous near the former, and especially before the road reaches its summit near the Sugar Loaf. The rock is a hard and apparently indestructible greenstone slate, and the smallest scratches have been well preserved. Beyond the summit, the rock appears to be clay-slate; and though the peculiar swelling form of the surface may still be seen, I do not think that any scratches can be found. But in the hollow of Hungry Hill I saw one block (I do not remember of what stone) on which the scratches were perfectly preserved.

I had previously visited the country in the neighbourhood of Scull and Crookhaven, and had passed from it to Bantry. Although the rock is sufficiently exposed in this tract, and appears to be indestructibly hard, I did not remark any traces of glacier action. I have also passed to the north side of the hills dividing Kenmare from Glengariff; but in this tract the rock is not sufficiently exposed to make it probable that glacier-traces can be seen.

I think it right to add, that I have seen the marks of glaciers in the Alpine valleys close to the existing glaciers as well as at several miles' distance from them, and that I am perfectly familiar with their appearance. And I have no hesitation in pronouncing on the certainty of those whose position I have indicated above.

I am, my dear Lord, your very faithful Servant,

The Earl of Rosse. G. B. Airy.

Illustration of the agency of Glaciers in transporting Rocks. By Col. Sabine.

When the Antarctic Expedition had reached 78° S. lat. the vessels were stopped by a barrier of ice, from 100 to 180 feet in height, and 300 miles in extent from east to west; beyond these cliffs of ice a range of lofty mountains were visible about 60 miles distant, the westernmost of which appeared to be 12,000 feet in height. From the face of these ice-cliffs masses were constantly breaking off and floating northward, bearing with them fragments of rocks probably derived from the mountains from which the glacier appeared to descend. In the latitude of 66° and 67°, at a distance of 700 miles from the glacier, the ice formed a floating barrrier, through which ships could with difficulty force their way. Over the intermediate area the icebergs would be constantly strewing masses of rock and detritus, particularly at their northern limit, where they would probably form mounds resembling terminal glacial moraines. Colonel Sabine then described similar phænomena in Baffin's Bay, which he stated to be, in many parts, deeper than the thousand-fathom line, but comparatively shallow at the strait which forms its entrance. The bay was surrounded by alternate cliffs of rock and valleys occupied by glaciers, presenting cliffs of ice along the shore, from which masses became detached, many of which floated off to the zone of shallow water at the entrance of the bay, where they were arrested in their progress, and deposited the fragments of granite, trap, and limestone containing fossils, derived from different parts around the bay.

On the cause of the Motion of Glaciers. By William Hopkins, *F.G.S.*

De Saussure had adopted the theory which attributes this motion to the resolved part of gravity acting along the inclined surfaces on which all glaciers in motion are situate; and he explained, also, how the motion would be facilitated by the effects of the internal heat of the earth, and of subglacial currents. When the attention of philosophers, however, was recalled a few years years ago to this subject, and more accurate observations and admeasurements were made, the inclinations of the beds of glaciers were found in many cases to be so small (in the glacier of the Aar, for example, not exceeding three degrees), that it appeared extremely difficult to conceive how the force of gravity alone could be adequate to overcome the friction on the bottom and sides of the glacier, and the numerous local obstacles to its movement. Numerous experiments on the descent of bodies along inclined planes had shown, that when the surfaces of the bodies and planes were perfectly hard and polished, no motion would ensue without an inclination considerably greater than that of many glaciers; and, moreover, that the inclination required to produce motion was independent of the weight of the sliding body. These considerations led to the very general rejection of De Saussure's theory, and to the adoption, by many persons, of the *dilatation theory*, of which M. Agassiz had been the principal advocate. According to this theory, a part of the water produced by the dissolution of the superficial portion of the glacier during summer passed, by infiltration, into the minute pores and crevices of the glacier, where it was again converted into ice, and by its expansion in the process of freezing produced a *dilatation* and consequent motion of the glacier. It was manifest, however, that the frequent alternation of freezing and thawing within the glacier which this theory assumed, could not possibly take place at depths beneath its surface exceeding a very few feet, and therefore could not produce any sensible effect on the motion of the whole mass. This theory presented many other difficulties, of which no adequate solution had been given; and the author could not but consider it as contrary to the most obvious mechanical and physical principles. Another theory had also been put forward, which attributed the motion of glaciers to the expansion of water in the act of freezing, after it had filled, not the minute pores of the ice, but internal cavities of considerable dimensions. But, since the temperature of the glacier at considerable depths must be sensibly constant, how were new cavities to be formed when existing ones had been once filled up? The author, regarding both this theory and the preceding one as untenable, was thus led to examine how far the apparent objections to De Saussure's theory were really valid, by a series of experiments on the descent of ice down inclined planes. The experiments were made in the following manner:—a slab of sandstone, prepared to be laid down as a part of a common flagstone pavement, was so arranged as to be easily placed at any proposed inclination to the horizon. The surface of the slab, so far from being polished, retained the grooved marks of the instrument with which the quarryman had shaped it. A quantity of ice was placed on the slab, within a frame nearly a foot square, intended merely to keep the ice together, and not touching the slab, with which the ice alone was in contact. The following were results obtained in one set of experiments, the ice being loaded with a weight of about 150lbs. The temperature of the air was about 50° Fahr.:—

Inclination of the planes	3°	6°	9°	12°	15°
	inches				
Mean space descended through in one hour	0·31	·62	·96	2·	2·5

When the weight was increased, the rate of motion was also increased. The least inclination at which sensible motion would take place was not determined; but it was ascertained that it could not exceed *half a degree* in the case of a smooth but unpolished surface. With a *polished* surface of a marble slab, the motion of the ice indicated a deviation from horizontality with as much sensibility as water itself. It will be observed, in the results above given, that (1) the motion was unaccelerated; and (2) it increased with the inclination, and (when the inclination was not greater than nine or ten degrees) in nearly the same ratio; and (3) the rate of movement was of the same order of magnitude as in actual glacial motion, which may be stated generally, in cases yet observed, never to exceed two feet a day. The extremely small friction between the plane and the ice, indicated by the small inclination necessary to produce motion, was manifestly due to the circumstance of the lower surface of the ice being in a state of gradual disintegration, which, however, was extremely slow, as proved by the small quantity of water proceeding from it. In the application, therefore, of these results to the case of actual glaciers, it was necessary to show that the temperature of their lower surfaces could not generally be less than 32° Fahr. Such, the author stated, must necessarily be the case, unless the conductive power of ice was greater than it was deemed possible that it could be. He considered the sub-glacial currents as powerful agents in the disintegration of the lower surfaces of glaciers, especially near their lower extremities. The results of Prof. Forbes's observations on the motion of the Mer de Glace of Mont Blanc, afforded, as regards that glacier (and, by inference, as regards all other glaciers), a complete refutation of the theories which attribute glacial movements to any expansion or dilation of the ice. The Professor had, however, put forth a new theory, which agreed with that offered by Mr. Hopkins in attributing glacial motion to the action of gravity, but differed from it entirely as a mechanical theory in other respects. The Professor appeared to reject the sliding theory of De Saussure on account of the difficulties already mentioned (which were now removed by the above experiments), and assigned to the mass of a glacier the property of *plasticity*, or *semifluidity*, in a degree sufficient to account for the fact of its descending down surfaces of such small inclination. According to this theory, the motion was due to the small cohesion of one particle of glacial ice to another. Mr. Hopkins stated his conviction that the internal cohesion of the mass was immensely greater than its cohesion to the surface on which it rests, whenever the lower surface is in a state of disintegration. It was perfectly consistent with this conclusion to assign to the glacier whatever degree of *plasticity* might be necessary to account for the relative motions of its central and longitudinal portions, under the enormous pressure to which, according to his theory, he showed it might be subjected. Such relative motions, however, were probably facilitated more by the *dislocation* than the plasticity of the mass. Sufficient, he trusted, had been advanced to prove that the *sliding theory* assigned a cause adequate to the production of all the observed phænomena of glacial movements. With respect to the transport of erratic blocks and detritus from the Alps to the Jura, Mr. Hopkins observed that the greatest height which glaciers had formerly attained in the valley of the Rhone (whence a large portion of the erratics had been derived), appeared to be well defined by lateral moraines and polished rocks, while the greatest height at which these blocks had been deposited on the Jura was also well defined. Thus, according to M. Charpentier, the Rhone glacier must have risen, at the mouth of the valley, to about 2500 feet above the existing surface of the Lake of Geneva; while the highest band of detritus on the Jura was stated to rise to a still higher level. It was inconceivable, therefore, that such detritus should have been lodged at its present elevation by former glaciers. The only way in which it appeared possible to obviate the mechanical difficulties of the subject, was to suppose the transport to have been effected when the Jura was at a lower level relatively to the Alps, and the whole district lower relatively to the surface of the ocean. In such case, the space between the Alps and the Jura may have been occupied by the sea, and the ice, with its transported materials, may have passed from the former to the latter chain, partly with the character of a glacier, and partly with that of an iceberg. This hypothesis is perfectly consistent with the supposition of the general configuration of the surface of the Jura having been the same at the epoch of the transport as at the present time; and Mr. Hopkins believed it would be found equally so with all the observed phænomena of that region.

Mr. Murchison exhibited a Relievo Map of England and Wales, prepared by Messrs. Dobbs and Co., and coloured geologically under his own direction. He pointed out the accordance between the physical features of the country and the boundaries of particular strata, and stated generally the dependence of geographical contour upon the geological structure of any region and the mechanical forces to which the rocks had been subjected.

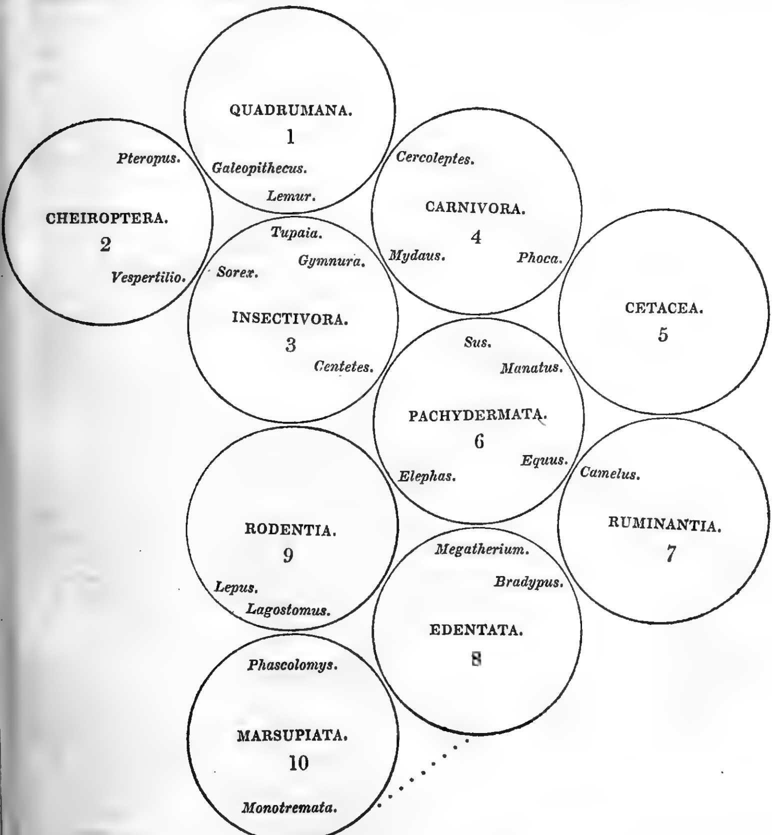
Mr. E. Hall exhibited his Maps and Sections illustrating the geological structure of Derbyshire and the Lancashire Coal-field.

Prof. E. Forbes exhibited a Map of Lycia, by Lieut. Spratt.

ZOOLOGY AND BOTANY.

On the Classification of the Mammalia. *By* G. R. Waterhouse.

The paper is chiefly explanatory of the following tabular arrangement, in which the author has attempted to group the various orders of the class *Mammalia*, so as to display their mutual relations.



In this table the circles 1 to 9 inclusive, comprise the nine orders of Placental Mammalia, and the circle 10 represents the Implacental, or Marsupial order. The placental series appears to divide itself into two great sections; the first or highest embraces the order *Quadrumana, Cheiroptera, Insectivora,* and *Carnivora,* the species of which possess the four kinds of teeth, viz. incisors, canines, false molars, and true molars, in a well-developed condition. They are chiefly animals of prey, carnivorous or insectivorous, if we except the first order, containing those mammals which in all their characters approach most nearly to man, and are chiefly frugivorous.

The author proceeds to point out the peculiarities in the brain as observable in these great sections, but remarks he is not prepared, in our present state of knowledge of this organ, to follow those naturalists who would found a classification chiefly upon its modifications; certainly not upon those pointed out. He is not satisfied that in all instances a highly developed brain is accompanied by a corresponding degree of intelligence. Thus, for instance, the brain in the Cetaceans is very highly organized, but we should perhaps take into consideration that the brain has to be educated from without, and when we perceive the imperfections in the educatory media—the senses, in the Whales, where the organ of smell is either wanting or exists only in a very rudimentary condition; where the hands are transformed into fins, covered by a common integument, we can conceive that the highly organized brain is given to the Whale to compensate for these deficiencies, and that its intelligence is not necessarily in degree equal to what might be inferred from the consideration of the brain abstractedly. The same remarks will apply to a certain degree to the brain of the Seals. The brain of *Stenops* is instanced as a case of a comparatively low brain in one of the highest order of Mammalia.

As regards the Cetaceans, although the condition of the senses may be taken into account in considering the brain, with a view to forming an estimation of their intelligence, the author is of opinion that so highly organized a brain as is possessed by that group, forbids its being placed at the end of the class, as has been done.

On the whole, the Cetacea are perhaps most conveniently located between the great carnivorous section and the herbivorous, as in the table. They may be connected with the *Pachydermata* through the Lamantins, and with the *Carnivora* through the Seals. The author follows De Blainville, Owen, and some other naturalists, in separating the Phytophagous genera, *Manatus*, *Halicore* and *Rytina*, from the true Whales, with which they are associated by Cuvier. The animals constituting these three genera he regards as aquatic *Pachydermata*, bearing the same relations to the ordinary Pachyderms as do the Seals to the *Carnivora*.

In the circles representing the orders are introduced those genera, belonging to each, which appear to approach most nearly to other orders. Most of these approaches of genera of one order to the general characters of other orders have been before pointed out; he does not, however, see good reasons for the belief (expressed by some) that the groups pass imperceptibly into each other; were that the case, there would be many species so well balanced in their characters that they could not, in a classification, without doing violence to those characters, be placed in any particular order; they would require to be arranged *between* the orders the characters of which they combined. Species which even *appear* to require to be so located are, however, at least far from numerous, and in proportion as the knowledge of the groups and species increases, so does the number of supposed links decrease; it becomes less and less doubtful in which group an animal should be placed. Instances illustrative of this point are mentioned. The question is (the author observes), whether any species is framed essentially on two types of the same rank? Each animal is framed to perform certain functions, and is perfectly adapted to those functions, but beyond this, is not each species framed upon some general and particular model? Certainly it may be said with respect to the Water-rat (*Arvicola amphibia*), that it is framed on the Vertebrate model; on the Mammalian type of that model; on the Rodent type of the *Mammalia*; and it is equally clear to the senses that it possesses the same general structure of skull, combined with the anchylosed fibula to the tibia, &c., which characterize the murine family of the Rodent order. Beyond this, again, it exhibits a modification in the structure of the teeth, in which it agrees with numerous other species of the family mentioned, and which are classed under the generic title *Arvicola*. So that, in one sense, the Water-rat may be said to be essentially framed upon more than one model, but from the lowest to the highest of the divisions mentioned, each model is a modification of the type of the division which precedes it, and the case might be therefore symbolically represented by concentric circles of different sizes, the largest of which would typify the *Vertebrata*, and the smallest the genus *Arvicola*. It does not appear that the Water-rat is framed upon two or more types of *equal rank*, and the author strongly inclines to the belief that what is true of one species, as regards the point under consideration, is true of all.

He next calls attention to another point connected with the genera introduced in the table, observing, that it often happens that those species of one order which approach most nearly to other adjoining orders, are not met, as it were, by a corresponding approach in those adjoining orders. Each order may throw out rays (to speak figuratively) to other orders, but the rays are seldom in the same direction. Among the *Carnivora*, the genus *Mydaus*, in general appearance, and in its insectivorous diet, resembles the species of the order *Insectivora*, but it differs widely in dentition, having but one true molar to each side of each jaw, as in others of the group to which it belongs. On the other hand we find a considerable approach evinced in the genus *Gymnura* (one of the *Insectivora*) to the carnivorous order, displayed in the general form of the skull, in the presence of six incisors (a number unusual in the *Insectivora*), and well-developed canines. Here is a case of one of the *Insectivora* approaching the *Carnivora* on the one hand, and of one of the *Carnivora* approaching the *Insectivora* on the other. But the two animals mentioned do not approach towards each other in corresponding modifications of structure. Several other illustrations of this point are noticed in the paper, which then proceeds to give some general observations on dentition, and characters derivable from other parts, with a view to show the kind of connexion which exists between the several genera introduced in the table, and the orders to which they are approximated. In none of the instances of approach of species of one order to other orders alluded to in the paper, does the author perceive a case which would, in his opinion, fully bear out the notion that the orders imperceptibly blend into each other. There is always (he observes) a tolerably well-marked line between them, hence he has inclosed the orders in circles. The aberrant species are readily traced back, as it were, into their own groups, and when they evince an approach to other circles, it is rather to the order, than to any particular species of the order.

In conclusion, he offers the following propositions and observations for consideration:—

Species of animals belonging to the same genus have an affinity to each other; genera of the same family have a mutual affinity; relationship of affinity may likewise exist between families of the same order, and orders of the same class, *but the degree of affinity is different in the different cases.* Thus,

species of the same genus have an affinity of the first, or nearest degree;
species of different genera have an affinity of the second degree only;
species of different families have an affinity of the third degree only;
species of different orders have an affinity of the fourth degree only;
species of different classes have an affinity of the fifth degree only.

A relationship may exist between species of different groups which differs from either of the cases just mentioned,—that which is commonly termed by naturalists a "relationship of analogy." This again may vary in degree according to the affinities and relative rank of the groups which present the cases of analogy. The analogy may be more or less remote. Thus the case of analogy (so often quoted as such) as existing between the Goat-sucker (*Caprimulgus*) and the Bat—members of different classes—might be expressed as one—say of the fifth degree; that of the Otters to the Beavers (animals of different orders of the same class) an analogy of the fourth degree; and that of the Beaver to the Coypu* (*Myopotamus*), an analogy of the third degree. Again, the relationship existing between the Whales and Fishes may be one of analogy of the fifth degree, that existing between the Dugong and the Porpoise may be one of affinity or analogy, but in either case is less remote than the relationship of the *Cetacea* to the fishes.

According to these propositions, moreover, the relationship of the Lagostomus to the *Marsupiata* might be one of affinity of the fourth degree, whilst that of the Wombat to the Rodentia might be one of analogy of the same degree; that of the Wombat to the *Phalangistidæ*, an affinity of the third degree; and of the Koalu (*Phascolomys*) to *Phalangista*, an affinity of the second degree; and lastly, that of *Phalangista vulpina* to *Phalangista Cookii*, an affinity of the nearest, or first degree. The affinity of the *Monotremata* to the class *Reptilia* would be several degrees further removed than that of the *Echidna* to the *Ornithorhynchus*†.

On the Physical Character, Languages, and Manners of the People of the Navigators Islands. By Mr. Heath.

The islanders were described as a fine race of people, the average size rather above that of Europeans—the colour brunette, the face oval, the hair black and rather crisp,

* These two animals are essentially modelled upon different types of the Rodent order.

† The *Monotremata* are placed with the *Edentata* by Cuvier, but Mr. Waterhouse regards the Monotremata as constituting an aberrant group of the *Marsupiata*: their relationship with the true *Edentata* is certainly one of analogy only.

and the eyes a fine black. Their language is at present scarcely known to philologists. It is spoken by about 60,000, and is a dialect of the wide-spread Polynesian. One of its marked peculiarities is, its reciprocal conjugation of the verb. Mr. Heath had entered very fully into a comparison of the Samoan with the Malay, and of several of the Polynesian languages among themselves, and of some of the Papuan dialects, and had obtained extensive vocabularies. With regard to individual and family life, the child is named after the god whose name is last invoked prior to the moment of birth. The mothers slightly press the forehead so as to give it a conical form: they rear their children tenderly. Circumcision is practised. They believed in a future state, but had rather loose and inconsistent notions as to what sort of state it is; some, they said, became gods, some were eaten by the gods, and the chiefs became living pillars in a large temple. The tradition with them is, that they came from the westward, and their elysium is Pulotu. Since Pulo is the name for island, this also indicates their origin. They are an intelligent people, and manifestly capable of improvement. The people of Tanna and the neighbouring island are in stature about five feet six or five feet eight, the legs rather short and ill-formed: they are neither so well-formed or well-featured as the Samoans and other Polynesians. The complexion is the colour of dirty or worn copper coin, and they make their skin still darker by a deep purple-dye; they also daub their faces with red, black, and other pigments. There is a mixture of the Papuans and Polynesians, for the people of Erranan and Immer have dialects very similar to the Samoan, and there are intermarriages between the tribes, so that the Polynesians are now nearly as dark-coloured as the Papuan. Various dialects were found, not only in the group, but even on one and the same island. The language spoken at Port Resolution is in some respects peculiar; it has a conjugation of the verb by prefixes, and not only a dual but a triple personal pronoun. The people of Tanna sometimes bury their dead in shallow graves, sometimes tie a stone to them and sink them in the sea. At Anatom, the widow is tied, alive, to the dead body of her husband, and sunk together with it in the sea.

Dr. Harvey furnished a catalogue of the Vertebrata of the county of Cork as compared with those of Ireland generally, and Great Britain; by which it would appear, that of 630 vertebrated animals, natives of the British Isles, there are 445 found in Ireland, and of these 285 in the county of Cork. There are of—

	British.	Irish.	Cork.
Mammalia	67	28	23
Aves	312	253	161
Reptilia	15	7	2
Pisces	236	157	99

Turdus Whitei, *Sciæna aquila*, and *Naucrates ductor*, included in this catalogue, had not been observed before in Ireland. *Glareola pratincola* is noticed as having once been shot in the county of Cork, but the specimen was not preserved.

On Certain Peculiarities in the Arteries of the Six-banded Armadillo. By Dr. Allman.

The peculiarities noticed in this communication consist in a remarkable arrangement of vessels, analogous to what has been already observed in the Sloths, in the two-toed Anteater and in the Lorises, and is characterized by the arteries having a tendency to *divide* rather than ramify; from which it results, that instead of a diffusely branched arterial distribution, the larger branches suddenly break themselves up into a number of small vessels, which anastomosing but sparingly, give rise to a series of vascular pencils, from which the ultimate supply of blood to the organs is derived. This remarkable arrangement is chiefly displayed in the arteries of the posterior extremities, in the caudal arteries, and in the epigastric.

Mr. Thompson exhibited specimens of the Alpine Hare (*Lepus variabilis*), from the Highlands of Scotland, and of the Hare of Ireland (*Lepus hibernicus*), for the purpose of showing that the species are identical. Of this fact he, judging from external characters, satisfied himself last autumn, when in the Highlands of Scotland, and subsequently proved it by a comparison of the anatomical characters of the two supposed species.

Description of a Chart of the Natural Affinities of the Insessorial Order of Birds. By H. E. Strickland.

At the Glasgow meeting, in 1840, Mr. Strickland had first proposed his plan for exhibiting the affinities of allied organic forms, by a process analogous, in some respects, to that of map-making. He now exhibited a large chart constructed on this plan, and showing the affinities of the genera in the order Insessores. The name of each genus is inscribed in an oval cartouche, and its affinities to other genera are indicated by connecting lines, the lengths of which lines are approximately proportionate to the remoteness of the affinities. Those genera which are most nearly allied are connected by a line of *one* degree, or unit, in length; and those less closely allied, by a line of *two* degrees. Genera so distant as to require to be placed in different *sub-families*, are united by lines of three or four degrees; those in different *families* by lines of five or six degrees; and those in different *tribes* by lines of seven or eight degrees. A line is drawn round those genera which constitute one sub-family, and the area thus inclosed is coloured, the surrounding space being left white. The sub-families which belong to the same family, are distinguished by the same colour; and the families are inclosed within a dotted line; while the boundaries of the tribes are marked by a red stripe. The names of the respective groups are inserted; and the whole assumes the appearance of a cluster of islands depicted on a map. The author expressed his belief that the true affinities of organized beings may be expressed with greater accuracy and conciseness by this method than by any other with which he was acquainted. Being a purely inductive process, the details of any branch of natural history may be in this way worked out and depicted without recourse to any theoretical assumptions. One result of it seems to be, that the true affinities of organic structures branch out irregularly in all directions, and that no symmetrical arrangement or numerical uniformity is discoverable in the system of nature when studied independently of preconceived theory.

Periodical Birds observed in the years 1842 *and* 1843 *near Llanrwst, Denbighshire, North Wales.* By John Blackwall, *F.L.S.*

Birds.	Appeared.	Disappeared.
	1842.	1843.
Redwing, *Turdus iliacus*	Oct. 1	
Woodcock, *Scolopax rusticola*	,, 7	March 25
Mountain Finch, *Fringilla montifringilla*	,, 18	
Fieldfare, *Turdus pilars*	Nov. 6	April 5
	1843.	
Pied Wagtail, *Motacilla alba*	March 13	
Yellow Wren, *Sylvia trochilus*	April 10	
Common Sandpiper, *Totanus hypoleucos*	,, 11	
Redstart, *Sylvia phœnicurus*	,, 16	
Swallow, *Hirundo rustica*	,, 16	
Sand Martin, *Hirundo riparia*	,, 17	
Tree Pipit, *Anthus arboreus*	,, 17	
Cuckoo, *Cuculus canorus*	,, 20	July 3
Lesser Pettychaps, *Sylvia hippolais*	,, 21	
Black-cap, *Sylvia atricapilla*	,, 21	
White-throat, *Sylvia cinerea*	,, 23	
Wood Wren, *Sylvia sibilatrix*	,, 24	
Land Rail, *Gallinula crex*	,, 24	
Whinchat, *Saxicola rubetra*	,, 29	
Pied Flycatcher, *Muscicapa luctuosa*	May 2	
Swift, *Cypselus murarius*	,, 5	Aug. 10
House Martin, *Hirundo urbica*	,, 6	
Pettychaps, *Sylvia hortensis*	,, 9	
Sedge Warbler, *Sylvia phragmitis*	,, 10	
Red-backed Shrike, *Lanius collurio*	,, 11	
Spotted Fly-catcher, *Muscicapa grisola*	,, 14	
Goat-sucker, *Caprimulgus europæus*	,, 19	

On the Structure and Affinities of Upupa, *Lin., and* Irrisor, *Lesson.* *By* H. E. Strickland, *F.G.S.*

The African genus *Irrisor* of Lesson has been classed by various authors in the genera *Upupa*, *Merops*, and *Epimachus*, but as it is distinct from all these, and also from Brisson's genus *Promerops*, by which name later authors have called it, the term *Irrisor* of Lesson becomes its legitimate appellation.

Most authors have placed *Irrisor* very near *Upupa*, but the Baron Lafresnaye (in Proc. Zool. Soc. 1840, p. 124), maintains that they have no immediate affinity, and places *Irrisor* among the *Nectariniidæ*, and *Upupa* in the same family with *Upucerthia* and its allied genera. It is true that there are considerable differences between these genera. In *Upupa* the plumage is ferruginous, the head crested, the tail even, with ten rectrices, the lateral toes nearly equal, the outer and middle ones divided to their base, the anterior claws short and blunt, and the hind claw nearly straight, a structure conformable to its terrestrial habits. In *Irrisor* the plumage is metallic black, the head not crested, the tail graduated, with twelve rectrices, the outer toe longer than the inner, united to the middle one by its basal joint, and the claws curved and sharp, indicating arboreal habits. But on the other hand, the beaks of these genera possess in common two peculiarities of structure, overlooked by previous naturalists, but which are believed to occur in no other known group of birds. These are, first, the perfect flatness of the inner surfaces of both mandibles, so that when closed they are brought into perfect contact, leaving only a small space at the base for a short obtuse tongue; and secondly, a narrow groove along the ridge of both mandibles towards the apex. In *Upupa* this groove is single, in *Irrisor* it is divided by a fine longitudinal ridge.

The author of this paper contended that the peculiar characters of the beak, common to *Upupa* and *Irrisor*, but found in no other known group of birds, indicate, not an analogy, but a real affinity between them, and must therefore, taken in connection with minor points of agreement in the form and style of colouring of the wings, and in the mode of nidification, be considered to preponderate over the various points of difference. We must therefore continue to class *Upupa* and *Irrisor* (together with *Rhinopomastus*, which is hardly distinguishable as a genus from the latter), in one and the same superior group, *Upupidæ*. The next question is, in what part of the natural system the group *Upupidæ*, so restricted, is to be placed? They are certainly a very insulated group, but the combination of a long beak with a short tongue seems to show an affinity in one direction to the *Alcedinidæ*, and in another they probably lead through *Epimachus* to the *Paradiseidæ*. We require, however, much fuller details respecting the habits and anatomy of these birds before their true place can be determined with certainty.

Mr. Strickland read to the Section a Catalogue of the Birds found in Corfu and the Ionian Islands, by Capt. H. M. Drummond, 42nd R.H.—In this list, which is of considerable extent, Capt. Drummond has inserted many valuable observations on the habits and migrations of the birds which occur in the Ionian Islands. The total number of species in the list is 200;—of these 160 are British, 39 are found on the European continent, but not in Britain, and 1, the *Calamoherpe olivetorum*, Strickland, has hitherto been found only in the Ionian Islands, where it is very common during the summer.

Mr. Strickland presented a similar list, by the same gentleman, of the birds of Crete, made during a visit to that island in May and June 1843, in company with Capt. Graves of H.M.S. *Beacon*.—From the shortness of the author's stay in Crete, this list is less complete than the last, but embodies many interesting facts. The total of species observed was 105, of which 86 are British and 19 continental. It is remarkable that the common sparrow of Crete is the *Fringilla cisalpina*, while, in the Ionian Islands, it is replaced by the *F. domestica*. Mr. Strickland expressed his pleasure at the progress of Capt. Drummond's ornithological researches. Such lists were of great value in forming tables of the distribution of animal life, and he bore testimony to the accuracy of Capt. Drummond's observations.

Mr. Strickland exhibited to the Section the beautiful work of the Prince of Canino, called *Fauna Italica*, the fruit of ten years' labour. The Prince had, unfortunately, been prevented from attending this meeting, in consequence of the approaching scientific congress at Lucca, in September, but he had promised to be present at the meeting next year.

Mr. Thompson exhibited to the Section a specimen of the *Pycnonotus chrysorrhœus*, Swainson, shot near Waterford in January 1838, and belonging to Dr. Burkitt, of that city. This species of bird is a native of Africa, and has not before been noticed as visiting Europe.

Dr. Lankester read the following extract of a letter from Mr. Denny, of Leeds:—"During the recent meeting of the Provincial Medical Association in Leeds, a medical friend of mine informed me that a pair of grey parrots had hatched and reared a young bird in his village. This struck me as something novel; at least, so far as rearing the young parrot was concerned, as I was previously aware that parrots will lay eggs in this country, but I have never heard of an instance of hatching. I therefore put down several queries for my friend to get me answers to on his return, which I now forward to you, thinking it might interest some of the members of the British Association at Cork:—'The two old birds were purchased in the market at Sierra Leone, in 1840, when about six months old, and brought to England in the same cage; but were then separated until February 1842, the male being left at Hull and the female brought to Riccal. She first commenced laying in July 1842, and laid three eggs, which were taken from her as she laid them. She began to lay this year about the 10th of June, and laid two eggs, which she sat on exactly four weeks, and brought off one bird only, which was hatched on Sunday, July 16th. They are fed upon boiled flour pudding, which the old birds masticate and feed the young bird with. The old lady, the owner, also frequently chews a little pudding and allows the young bird to take it from her mouth. Both birds sat upon the eggs in turn, and the male frequently pushed the female from the eggs for the purpose. The young bird was blind about sixteen days, and quite bare of feathers or down. It can now (August 5) see, and is beginning to be downy, and is growing very fast, and appears a very strong bird.'" Dr. Lankester also exhibited from Mr. Denny, a specimen of a Carabus, completely covered with parasites, which he supposed to be *Europoda vegetans*.

Mr. Thompson called attention to the circumstance of the nidification of the Woodcock in Ireland, with especial reference to Tullamore Park, in the county of Down, the seat of the Earl of Roden. Here the species was first observed to remain throughout the summer and rear its young in 1835, since which period the numbers so remaining have been gradually on the increase, and in the present year twenty-two nests have been found; so that woodcocks are now as plentiful in summer as in winter in the park.

Mr. Ball exhibited a drawing of *Cuculus glandarius* taken from a specimen of the bird which had come under his notice. It is the property of Mrs. Creighton, and was captured on an island near Clifden, in the county of Galway, in March last. This is the first recorded instance of the occurrence of the species in the British Islands. It is well known in Africa and Southern Europe.

Mr. Humphreys read a paper on the Mollusca of the county of Cork, of which he enumerated 230 species, besides 55 species of the Articulata, and 25 of the Radiata.

On the Microscopic Structure of Shells. By W. B. Carpenter, *M.D.*

The author stated that all the solid calcareous shells of molluscous animals possessed organic structure, in the same manner as the teeth of the higher orders of animals; amongst recent shells this structure is characteristic of various natural groups, and will, therefore, probably afford valuable assistance in the determination of fossil genera and species. The principal varieties of structure were described as consisting of modifications of two simple forms, the Cellular and the Membranous. Of the first of these, the Pinna affords a good example: it consists of prismatic cells, like the cellular tissue of vegetables, filled with carbonate of lime; and if placed in acid, the lime will be removed, and the membrane alone remain, still preserving its cellular structure. In old specimens of the Pinna the animal matter is sometimes destroyed, leaving only the calcareous part of the shell, composed of minute spiculæ of carbonate of lime, which crumble under the finger. Cellular structure is found in all shells belonging to the order Margaritaceæ. With these the Pinna should be placed, since the Mytilaceæ, with which it has been hitherto classed, possess a different structure. Deshayes, in the new edition of Lamarck, upon a comparison of the characters of the genus Pinna, considers it more nearly allied to Avicula than Mytilus. In the fossil genus Inoceramus, traces of the cellular membrane may be discovered by dissolving the shell in weak acid. This structure also forms a thin layer between the epidermis and the nacre of Unionidæ; and also exists in the Ostraceæ. Dr. Carpenter has not found it in any shell not belonging to these natural families, except the anomalous genus Pandora. The second class of shells described by the author includes those possessing the Membranous Structure. In these the calcareous matter is deposited in laminæ, separated by excessively thin membrane, which forms, in fact, a secreting surface. This membrane does not lie flat, but is usually extremely corrugated and folded, and these folds being repeated in a regular manner, give rise to the nacreous lustre of the shells. Fragments of the Haliotis, after being laid in acid for a week, are still nacreous. A similar structure is also found in the Cowry and other porcellaneous shells, which are composed of three layers, the direction of the folds being different in each layer, as seen in the fracture of the shell. Another peculiarity in the internal structure of some shells consists of *minute tubes*, ramifying copiously over the different layers of membrane, and sending branches into the adjoining laminæ. Both the membranous and tubular structure are found in the *Avicula cygnipes* of the lias, showing that it belongs to the natural order Pectinidæ, and not to the Margaritaceæ. Prof. Phillips was aware, at the time he published this species, that it was nearly allied to the genus Lima and other Pectinidæ. The structure of the Brachiopoda is peculiarly plicated; and in the true Terebratulæ all the laminations are perforated by minute holes, going quite through the shell. In a transverse section these perforations are seen to enlarge as they approach the inner surface, forming funnel-shaped openings, lined by a membranous prolongation of the mantle, which is closely adherent to the inner surface of the shell. In one recent species, the *Terebratula psittacea*, the perforations are wanting; but in this species the structure of the hinge is also different, bringing it near a particular division of the fossil Brachiopoda (Atrypa, Dalman). Most of the fossil Terebratulæ that are *deeply plicated* also want the perforations, and these probably constitute a separate group. In concluding, Dr. Carpenter pointed out some of the peculiarities in the structure of the skeletons of the Echinodermata, which have been noticed by Valentin in his Monograph. The calcareous plates of an Echinus consist of numerous thin laminæ, connected by little pillars; and as the laminæ are perforated all over, whichever way a section is taken it exhibits a minute net-work. Dr. Carpenter stated that before becoming acquainted with the observations of Valentin, which are confined to the genus Echinus, he had detected a corresponding structure in all the families of the class. Dr. Carpenter also exhibited diagrams of several beautiful forms of structure in the spines of different species of Cidaris, and in the plates, forming the column of several fossil and recent Pentacrinites, showing that a different arrangement of the internal particles obtained in every species. This structure is well preserved in the fossil species, although they possess a regular crystalline cleavage.

On the addition of the order Nucleobranchia to the British Molluscous Fauna. By Professor E. Forbes.

Four years ago the author noticed minute needle-shaped animals floating under the surface of the water of the Frith of Forth and of the British Channel, which, when examined under the microscope, presented several anomalous characters, which rendered their true position in the animal series doubtful. At the time he was able to make but an imperfect examination of them, which he laid before the Wernerian Society. He has since met with much larger animals, belonging to the same genus, inhabiting the Mediterranean sea, which enabled him to refer them to the genus Sagitta of Quoy and Gaimard, placed by those naturalists in the immediate neighbourhood of Firola, in the order Nucleobranchia. Both the British and Mediterranean animals have linear-lanceolate bodies, terminated anteriorly by an oval head, and posteriorly by a horizontal tail. Along the sides are two pair of fins, also placed horizontally, the undermost pair being large in the British, and extremely small in the Mediterranean Sagitta. From the latter the following points of structure were made out. On each side of the head is a row of curved bristle-like processes, which can be erected or depressed at the will of the animal. On the head are two distinct black eyes. The mouth opens into a straight intestine, terminating in a vent where the body begins suddenly to contract, at about two-thirds of its length. On each side of this vent, but opening on the opposite side of the body, is a slightly curved canal, terminating in a *cul de sac*, and resembling closely the canals which contain the pinnated appendages of the Cydippe, but empty. The fins are of various shapes, and appear to form a sound basis for specific distinctions. They are rayed. The length of the largest specimen was two inches. The British examples were very minute. M. D'Orbigny has figured and described several species of Sagitta, which he observed during his South American voyages; but the details of his observations do not exactly coincide with those of Professor Forbes. The body which D'Orbigny styles a heart was not seen by the latter in any case; and the only circulation observed was an obscure movement of fluid with granules in the posterior part of the body behind the anus. No appearances of cilia were seen on the external surface. The author concluded, that however anomalous the characters of these curious animals might seem, it was nevertheless convenient, and probably correct, to arrange them among the nucleobranchous mollusca. He proposes to name the Mediterranean form *Sagitta Mediterranea*, and the British *Sagitta Britannica*. To the same order he was inclined to refer the shell called, by Dr. Fleming, *Fusus retroversus*, and which appears to be identical with, or at least very nearly allied to, the *Atlanta trochiformis* of M. D'Orbigny.

On some new Species of Mollusca nudibranchiata, *with Observations on the Structure and Development of the Animals of that Order. By* Messrs. J. Alder *and* A. Hancock.

The species described were a beautiful Calliopœa, the first discovered in Britain, and four new species of Eolis. The authors gave an account of their observations on the development of the ova in that order, stating the remarkable fact of these animals undergoing a complete metamorphosis, and being in their first or larva state, furnished with a nautiloid shell, which afterwards entirely disappears. They next alluded to some interesting anatomical peculiarities, describing the gastro-vascular system in Eolis, and the ejection occasionally of some curious bodies from the ends of the papillæ, apparently connected with this system. The organs of the external senses were next remarked upon, and the existence of organs of hearing in this class of gasteropods for the first time pointed out. They consist of small capsules filled with very minute concretions, which, in the living animal, are in a continued state of oscillation. Several reasons were also adduced for supposing that the dorsal tentacula of these animals are the true organs of smelling. The whole was illustrated by a series of drawings by Mr. Hancock.

Mr. Thompson noticed some additions to the Fauna of Ireland, comprising altogether in the various classes (excepting *Insecta, Entozoa* and *Infusoria*) about sixty species.

On the Irish species of the genus Limax. By the Rev. B. J. Clarke. *Illustrated by coloured drawings and living specimens.*

Two species were described in detail which had not been included by previous writers in the British Catalogue, the *Limax arboreus* of Bouchard, and the *L. Gagates* of Draparnaud and Ferussac. The occurrence of both had been noticed by Mr. Clarke in the Annals and Mag. of Nat. Hist. for 1840, but with some doubt, which subsequent observations had removed. Of *Limax arboreus* a minute detailed description was given, from which it would appear to be identical with the Limax so designated by M. Bouchard. But in the absence of specimens or figures for comparison, Mr. Clarke suggested the name of *L. glaucus*, as descriptive of its very peculiar hue, if it should not prove to be identical. The *L. arboreus* is not uncommon in the wooded districts of Ireland, especially on the ash and the beech, concealing itself during the daytime under the moss on the trunks.

Limax Gagates (Draparnaud).—The Irish specimens of this Limax agree with

Ferussac's variety β. The only British species with which it can be compared as to form is *L. Sowerbii.* In some districts of Ireland the species is not uncommon, frequenting gardens and thick herbage.

In the course of the paper all the British Limaces were mentioned as occurring in Ireland, with the exception of *Limax brunneus* (Draparnaud), which had not as yet come under the notice of the author.

Prof. Forbes exhibited several living animals which he had taken by means of the dredge off the coast of Cork. Some of these were but rarely taken; amongst them were a white variety of *Cypræa nattica, Ophiura texturata, Buccinum reticulatum, Ophiotoma roseola,* several species of corallines and various crustacea, and specimens of the genus Polycera, Eurastia, Trochus, and a hermit crab.

Prof. Forbes exhibited specimens of animals which had been dredged up on the coast of Ireland by Mr. Hoskyn, R.N. He then read a communication from Mr. Alder, describing a new species of mollusc found at Dalkey Island, near Dublin, having a shell in all respects similar to that of the genus Rissoa, from which, nevertheless, the animal differs materially. The most striking peculiarities were the presence of four tentacula, and the position of the eyes, which are placed on the back, at some distance behind the tentacula, and not at their base, as in Rissoa and the allied genera.

On Plumatella repens. *By* Dr. Allman.

The author divided his paper into two sections, in the first of which he gave the zoological characters of the Zoophyte, and in the second entered into the zootomical details of its structure. In the first part of the paper it was attempted to reduce to some sort of order the chaotic mass of synonyms with which the zoophyte in question was encumbered. This was facilitated by keeping in mind the existence of two variations which *Plumatella repens* is seen to assume. In one of these the zoophyte will be found attaching itself to flat surfaces, as the under side of stones, and of the floating leaves of water plants, &c., being closely adherent in its entire extent. In the second variation it will be found fixed to surfaces of small extent, as submerged stems and pieces of stick, and as the animal continues to develope, the branches having no extensive surface of attachment will become free, and a more or less entangled bushy mass will be the result.

Plumatella repens exhibits in a high degree of perfection the molluscan type of structure, and a distinct pharynx, stomach and intestine may easily be traced. Connected with the mouth, there is here, as well as in most other freshwater zoophytes of the same order, a very singular valve-like organ. This is situated between the mouth and the inner margin of the crescentic tentacular disc. Its form is somewhat that of the epiglottis in certain animals; it is convex towards the mouth, concave on the opposite surface. That surface which looks towards the mouth is covered with cilia, and to the other there is attached a sacciform membrane. The orifice of this sac corresponds with all the posterior surface of the valve, and to that portion of the tentacular disc which lies between the latter and the concavity of the crescent, and is thus completely closed, except at a small orifice in the disc, by means of which the sac of the valve would appear to communicate with the space between the body of the polype and the reflected tunic, and through this with the general cavity of the polype cell. The motion of the valve consists in a depression of this organ towards the mouth, followed by a return to its original position; and a rapid succession of these movements may frequently be observed. It is difficult to say by what mechanism the motion of the valve is effected, but it is very probable that it is the result of the injection of the sac with fluid through the opening in the disc.

The crown of tentacula is surrounded at its base by a caliciform membrane of extreme delicacy and transparency. This calyx is adherent to the tentacula for a short distance from their origin, but near its edge it becomes free, and hangs in loose plicæ from their sides.

The pharynx opens into the stomach by a distinct papilliform projection, which becomes prominent during deglutition. That part of the stomach which receives the pharynx consists of a remarkable elongation, occupying the place of the gizzard in many other zoophytes of this order, but in the present species not differing in structure from the rest of the stomach. To this portion of the stomach Dr. Allman gave the name of cardiac cavity.

On a line with the continuation of the cardiac into the great cavity arises the intestine from the upper part of the latter, and from the angle between the cardiac cavity and intestine the parietes of the stomach are prolonged into the great cavity obliquely across the pyloric orifice. By this arrangement the ventricular opening of the intestine is much contracted, and the prolongation of the walls appearing to act as a pyloric valve, will, under the influence of some vital stimulus, cause the alimentary matter to be retained in the stomach till fitted for passing into the intestine; and when the contents of the stomach have undergone the necessary change and passed the pylorus, the same contrivance will probably prevent any regurgitation.

Two distinct groups of muscles may be detected in *Plumatella repens*; one which corresponds with the anterior set of retractor muscles described by Dr. Farre in the Ascidian Zoophytes of the sea; and another analogous to the opercular muscles of this anatomist. These last muscles are peculiar and may be divided into two sets. The first consists of a set of irregularly disposed fibres which arise from the inner side of the internal tunic, commencing all round at the part where this tunic becomes united, near the orifice of the cell, with the external, and thence extending for some distance down the walls of the cell. From these points of origin fibres pass nearly horizontally inwards, and are inserted into the permanently invaginated portion of the internal tunic. The second set consists of a series of distinct muscular fasciculi, longer and stronger than the former; below which they arise also from the internal tunic, at regular intervals around the circumference of the cell, and in a plane perpendicular to its axis, and thence radiating inwards, are inserted into the opposed surface of the reflected tunic.

Of the structure of the ova of Plumatella, Dr. Allman gave the following account:—

The ova will be found to consist, as in those of Alcyonella, of a central disc, inclosing the embryonic matter, and of a rim which surrounds the disc, and from which it differs considerably in structure. The disc is formed of two membranes, each of which is composed of a single layer of minute vessels. These membranes differ from each other in the size of the component vesicles, and as there is but a single layer of vesicles in each, one face of the disc must consequently be thinner than the other. Both faces are concave on one side and convex on the other, and the concave sides being opposed and the edges united, a closed space is thus formed, which is filled by an immense number of minute whitish globules floating in a gelatinous fluid, and which are afterwards to be developed into the perfect zoophyte. The walls of the disc are of a horny elastic texture, of a deep brown colour, and when emptied of their contents, are found to possess some degree of transparency. Immediately surrounding the disc is the rim, equally wide all round, composed of two laminæ, united by their convex edges, and thence diverging to embrace the disc, which they overlap for a short distance. They inclose a cellular structure, the cells of which are irregular in form and arrangement. The rim is nearly colourless and transparent, and of a harder and more brittle texture than the disc.

Besides the bodies just described, others may frequently be observed closely resembling them in form, but never attached to the sides of the tube. These last bodies also differ from the mature ova, in their want of colour and in the softness of their texture, being easily broken down under the needle. That they are ova in an immature state there can be no doubt, their want of colour and softness of texture, and the fact of their never being found attached to the sides of the tube, being the only circumstances in which they appear to differ from the bodies which have been already described. These characters they would appear to retain till they have acquired their full size. Whether the attachment of the ovum to the sides of the tube be an invariable epoch in its history, it is not easy to determine; many which differ in nothing from the attached ova, are found to float freely in the fluid which immediately surrounds the body of the polype; and Dr. Allman has been unable to determine whether at any subsequent period they became fixed. The adhesion of the ovum to the sides of the tube is effected by an extra vascular unorganized substance resembling a varnish, transparent and brittle, and which is interposed between the thin face of the ovum and the parietes of the tube. Whether this uniting substance is poured out by the ovum itself, or secreted by the sides of the cell, or by some other part of the animal, it is impossible even to hazard an opinion. It is a singular fact, that it is invariably by the thinner of the two faces that the ovum becomes attached, and even in this simple occurrence, among these apparently insignificant organisms, a design is evident; for after the polype tube has become decomposed, and the ovum exposed to the influence of disintegrating agents, the free, and consequently unprotected, surface is by this arrangement always the thicker and the more resisting.

There would appear to be no possible way by which the ova can be liberated from the tubes but by the decomposition of the latter; and we accordingly find, after the zoophyte has entirely disappeared from the surface of the stone on which it crept, rows of these bodies occupying the place of the original polypidom, and mapping out its several ramifications. Notwithstanding the apparently complete destruction of the polypidom, the ova are found closely adherent to the substance to which the zoophyte had been fixed. This would appear to be effected through the medium of that portion of the tube to which they adhered; for the remainder of the polypidom becoming decomposed and washed away by the action of the water, this alone remains, being protected on each side from the influence of external agents.

When the progress of development has gone on for a certain time in the ovum, the faces of the disc separate from one another, each retaining that lamina of the rim which is connected with it. The young zoophyte being now at liberty, in all probability enjoys a power of free locomotion in the surrounding element, not becoming adherent till a subsequent period of its development. Though Dr. Allman has not succeeded in obtaining it in this free state, the supposition is borne out by the circumstance of his having frequently found the empty shells adhering to stones without any trace of the zoophyte; and also by the fact, that the change of state from the free to the fixed commonly prevails, not only among the genuine polypifera, but among the Ascidian Mollusca, an order of animals to which the subject of the present memoir possesses a much closer physiological relation than what is found to exist between it and the true polypes.

Dr. Allman exhibited to the Section, specimens of an Annelid, which he discovered some years ago in the bogs of the south of Ireland, and which was the cause of a luminous appearance. It was closely allied to the earthworm: when irritated, it gave out a phosphorescent light, which was also much increased when the animal was exposed to the vapour of alcohol. The light was of the peculiar green colour so usual on the phosphorescence of living animals. The Rev. F. B. Clarke had also found these annelids in the bogs of Connaught.

List of the Insects found in the county of Cork. By W. CLEAR, *F.L.S.*

When it became known that the British Association was about to visit Cork, it was proposed that lists of the Fauna and Flora of the county of Cork should be made out, as far as circumstances would permit, and the preparation of the list of insects devolved on Mr. Clear, as the only person who was known to have paid any attention to the entomology of that district. The list is so extremely imperfect, that the author desires it to be regarded only as a commencement. In it two orders, the Diptera and Hemiptera, have been altogether omitted, and several families, particularly those of minute size, have been scarcely noticed. The absence of a list of the dipterous insects is, however, the less to be regretted, as the insects of this order inhabiting the northern portion of Ireland have been already elaborated by A. H. Haliday, Esq. Mr. Clear's list consisted principally of Coleoptera and Lepidoptera.

Mr. Thompson, on behalf of Mr. Hyndman of Belfast, exhibited to the Section a specimen of that singular annelid, which forms for itself a quill-like case, the *Nereis tubicola* of Müller, described and figured in the 'Zoologia Danica.' The present is the first announcement of it as a British species. Three or four specimens were dredged from a depth of forty fathoms, off Sana Island, on the western coast of Scotland, by Mr. Hyndman, in July 1842.—Mr. Thompson also read a description, drawn up by Mr. Hyndman, of a species of hydrostatic Acalepha, taken in Belfast Bay, by Edmund Getty, Esq. in August 1841. It is the first record of any species of the family Physsophorida occurring in the British seas. The species being considered new, has been named *Apolemia Gettiana.*

Dr. Allman read a paper 'On the genus *Cirropteron*, Sars.'—In this communication it was maintained, that the genus Cirropteron had no real existence, having been founded by Sars on the imperfectly developed condition of a gasteropodous mollusc. Dr. Allman had himself bred from the ova of a gasteropodous mollusc animals referable to Sars' genus; and the singular ciliated disks with which the larvæ of buccinum, trochus, &c. are furnished, have been noticed by other observers. Dr. Allman called attention to the remarkable analogy which exists between these molluscan larvæ and the Rotiferæ, and advocated the necessity to the zoologist of an accurate knowledge, not only of the anatomy of the various organized beings which come under his observation, but of their history during the entire period of their existence.

On a new Genus of Terrestrial Gasteropod. By Dr. Allman.

This highly interesting animal was found last autumn in the county of Kerry by Mr. Andrews of Dublin. Dr. Allman examined it, and convinced himself of its entire generic distinctness and importance. It constitutes a connecting link between Arion and Limax, differing from the former in the possession of a well-developed internal shell, and in the position of the genital pore, which is placed, as in Limax, behind the root of the right small tentacle; and from the latter, in the orifice to the respiratory sac being in the anterior margin of the shield, and in its truncated glanduliferous tail. To the new genus, which it was therefore necessary to constitute for the reception of the gasteropod, Dr. Allman gave the name Geomalacus; and to the present species, the only one of the genus as yet discovered, the specific name maculosus is appropriated.

Synopsis of the Genera and Species of Zoophytes inhabiting the fresh waters of Ireland. By Dr. Allman.

The freshwater Zoophytes of Great Britain have hitherto been all included under the following four genera, Hydra, Cristatella, Alcyonella, and Plumatella. Of these, Hydra is made to include four British species,—Cristatella one, Alcyonella one, and Plumatella has been described as containing three species. Of the above nine species, the author was of opinion that two must be erased, viz. the *Hydra verrucosa* of Templeton, which appears identical with *H. fusca*, and the *Plumatella gelatinosa* of Fleming, which is evidently the same with Blumenbach's *Tubularia sultana*. To the seven species which remain, Dr. Allman was enabled to add five, of which four do not appear to have been before noticed, and the other is only found described in the Fauna of the Continent. The zoophytes at present included under Plumatella were distributed in the synopsis between two genera, those with crescentic discs being retained under Plumatella, while those whose discs are circular were removed to *Fredericella*, a genus established by M. Gervais for this form of ascidian zoophyte. An important addition now made to the British zoophytes is *Paludicella*, discovered by W. Thompson, Esq. at Lough Erne, in the autumn of 1837, and since obtained abundantly by Dr. Allman in the Grand Canal near Dublin. In October 1842, a hydroid zoophyte of much interest was discovered by Dr. Allman in the Grand Canal, Dublin; it is referable to no known genus, and occupies a position between Coryne and Hermia. For the reception of this zoophyte, therefore, he has been obliged to form a new genus, to which he has given the name *Cordylophora*. The synopsis, therefore, embraced several new species and two genera, now for the first time added to the British Fauna.

On the occurrence of Calothrix nivea, *and the Infusoria of sulphureous waters at Cove, Ireland. By* E. Lankester, *M.D., F.L.S., &c.*

At previous meetings of the Association the author had given an account of the occurrence of the *Calothrix nivea*, in most of the mineral springs of England and Scotland, as well as in other localities where sulphuretted hydrogen was spontaneously formed. He had also found with this plant several species of Infusoria, inhabiting sulphuretted hydrogen springs, some of these forming beautiful crimson deposits, at the bottom of the springs from which the water flowed. He had recently found the

Calothrix with the Infusoria, in the cavity of a rock on the sea-shore at Cove. As there did not appear to be a spring of sulphuretted hydrogen in this district, the author attributed the formation of this gas to the decomposition of the sulphates of the sea-water in contact with the decaying vegetable matter at the bottom of the cavity.

Mr. Mackay exhibited specimens of the Irish Saxifrages belonging to the Robertsonia or London Pride division, principally with a view of showing the kinds described by him in 'Flora Hibernica;' and more particularly to controvert a statement made by Mr. Babington, in a paper published by him in the 'Annals and Magazine of Natural History' for January 1842, that the *Saxifraga umbrosa* var. *α*. Flora Hibernica, the common London Pride of the gardens, was not indigenous to Ireland. He showed specimens taken from plants found by him on Connor Cliffs, near Dingle, in 1805, exactly agreeing with the figure in the Flora of the Pyrenees, by Lapeyrouse, and the London Pride of the gardens. He also exhibited specimens of the var. *β*, the most common appearance of the species on many of the Irish mountains, together with the rare and distinct var. *γ*. *serratifolia*, first found by him in the Gap of Dunloe, in 1805. He likewise exhibited specimens of *S. hirsuta*, Linn., first found by him in the Gap of Dunloe; also *S. elegans*, Mackay, found by him on Turk Mountain, Killarney, in the same year with the two last; and four varieties of *Saxifraga geum*, also first found by him in 1805, viz.—

α. Leaves hairy on both sides, rather obtusely crenate, scarcely distinct from *Robertsonia crenata* of Haworth; the most common variety of the species in gardens.

β. Leaves glabrous on both sides, sharply crenate, *Robertsonia dentata*, Haw. The most common variety on the Kerry and Cork mountains. The first variety is only found in low sheltered situations, and is very rare.

γ. Leaves light green, glabrous and shining, *Robertsonia polita* of Haworth. Found on Connor Hill, near Dingle, in 1805.

δ. *Gracilis*, Mackay. Plant small and slender, like the other rotundato-reniform, very small, hairy on both sides; flowers cream-coloured, spotless; scape slender. Connor Hill, near Dingle, 1805.

N.B. All the species and varieties here noticed have been cultivated in the College Botanic Garden for nearly forty years, and have not during that time become altered in their appearance.

The Rev. W. Hincks called attention to two living specimens of the *Neottia gemmipara* of Smith. This very rare plant had been discovered by Mr. J. Drummond, in a salt marsh near Castleton Bearhaven, in the county of Cork, in 1810. From an imperfect specimen, Sir J. E. Smith had described and figured it, and it had not been seen again till 1841, when it was re-found by Dr. Sharkey. Only one specimen was again obtained, and it was with difficulty identified with the original specimen in the Linnean Herbarium in London. Dr. Wood and Dr. Harvey had, during the past week, procured both living specimens, which were now on the table. The plant belonged to Smith's genus Neottia, but was now named Spiranthes.

Dr. Allman exhibited specimens of a Linaria which he had gathered in Ireland. He believed it to be a new species, and had described it at a meeting of the Royal Irish Academy. It had been supposed to be the *Linaria Italica* of Treviranus, which had also been found in England, but this plant differed in many respects from *L. Italica*. Dr. Allman then exhibited specimens of the very rare *Trichomanes speciosum*, and also of one discovered by Mr. Andrews of Dublin, which differed from it in many points, and which might probably turn out a new species; the principal features of difference that this fern presented were, the possession of bipinnate fronds, long bristles, and the triangular form of its fronds: in all these points it differed from *T. speciosum*.

The Rev. W. Hincks exhibited specimens of abnormal forms in the flowers of Fuchsia. He remarked that there were two series; the first, in which the petals, sepals and stamens were arranged in *fives*; the second, in which the sepals were in *threes*, whereas four is the normal number on which the parts of the flowers are arranged in the whole order Onagraceæ. The primitive number of the parts, in exogenous plants, is five. The first series, therefore, which exceeded the quaternary arrangement of its flowers, might be looked upon as a return to the primitive number. In the second series the number of parts was reduced by the adhesion of the parallel edges of two sepals.

Account of a Luminous Appearance on the Common Marigold, Calendula vulgaris. *By* RICHARD DOWDEN.

This circumstance was noticed on the 4th of August, 1842, at eight P.M., after a week of very dry warm weather; four persons observed the phænomenon; by shading off the declining daylight, a gold-coloured lambent light appeared to play from petal to petal of the flower, so as to make a more or less interrupted corona round its disk. It seemed as if this emanation grew less vivid as the light declined; it was not examined in darkness, which omission will be supplied on a future occasion. It may be here added, in the view to faciliate any other observer who may give attention to this phænomenon, that the double marigold is the best flower to experiment on, as the single flower "goeth to sleep with the sun," and has not the disk exposed for investigation.

Catalogue of the Plants found in the neighbourhood of Cork. By Dr. POWER.

Amongst rare plants found near Cork, were *Medicago maculata* and *denticulata*, and *Hypericum calycinum*. Plants, which were not uncommon in other districts and rare here, were also enumerated. The list contained 1425 plants, of which 624 were Cryptogamic.

Mr. Thompson exhibited to the Section a number of specimens of the phanerogamous and cryptogamous plants, of the county of Cork collected and named by Dennis Murray, a working gardener, among them were three species new to the Flora of Ireland, and twenty-two to that of Cork.

Mr. Babington presented three new aditions to the Flora of Cork. They consisted, first, of *Erica Mackayii*, which had been previously found only in Connemara; second, the *Erica cilians*; and third, the *Dabœcia multifolia*.

The Rev. W. Hincks read a communication from Dr. Wood, 'On the economical uses of certain Lichens.' The object of this paper was to draw attention to the fact that the *Lecanora tartarea* and *parella* grew in abundance about Cork, and that the collecting of these lichens as dyes might become a source of employment for the poor. Specimens of the plants were then exhibited.

MEDICAL SCIENCE.

On a peculiar Disease of the Biliary Ducts. By Dr. OLLIFFE.

THE affection to which he was about to call attention had never yet, he believed, been described by any author, and was of great importance, as it proved fatal in the case first brought under his notice. It occurred in the person of an officer who had resided for many years in India, and during that time suffered from the "Jungle Fever," or a peculiar intermittent of the tertian type, which was afterwards renewed in a slight form in Italy. Many years afterwards he was attacked by symptoms, not of an aggravated character at first, such as slight nausea every morning, but not amounting to vomiting, with debility. Then rigors of daily occurrence set in, followed by fever, terminating in diaphoresis; he seemed labouring under an attack of ordinary intermittent fever. The periodical symptoms were removed by the administration of quinine; but the debility increased, with some tenderness over the region of the liver, which appear to be hypertrophied. Notwithstanding the most careful treatment, conducted under the advice of the most eminent Parisian physicians, the patient died. On a *post-mortem* examination, the viscera of the great cavities appeared perfectly sound, with the exception of the liver, which was hypertrophied, but its general parenchymatous structure seemed healthy, with the exception of the mucous membrane of the biliary ducts, which was thickened, softened, and readily separable from the tissue beneath it; the ducts were enlarged and filled with a quantity of pus, and this through the whole organ, so that wherever an incision was made it oozed out. The veins were particularly examined, and were found quite natural. The gall-bladder was full of bile, mixed with pus. The mucous membrane of the entire alimentary canal was healthy. For this disease Dr. Olliffe proposed the name of "Purulent Catarrh of the Biliary Ducts;" and exhibited to the Section a cast, representing the condition of the liver on dissection. The cast was formed of the new material used by Dr. Felix Thibert of Paris, which possesses all the beauty of wax, and is much more durable, under all circumstances of temperature and casual violence.

On the Means adopted by Nature in the Suppression of Hæmorrhage from Large Arteries. By Dr. Houston.

It was not the author's intention to go into an examination or statement of the theories laid down on this subject, derived from experiments on the lower animals, (these experiments, although they might solve some general question, were, he observed, frequently deceptive when applied to a particular case in human pathology,) but to state accurately the appearances he found in a very remarkable case which had come under his observation and treatment. In it the entire arm had been suddenly torn off. The patient, a stout, healthy man, had been caught by a belt in a mill and thrown down with much violence; the arm which was caught was entirely removed; the man got up and walked down three flights of ladders without knowing that he had lost his limb. When removed to the hospital, the constitutional symptoms were very slight; the stump was covered with grumous blood, and was much lacerated; the nerves, particularly the median, hanging out several inches. There was no hæmorrhage, but a slight oozing. The brachial artery, when found, was tumified, smooth and soft at the extremity; strongly jerked by the pulsation of the heart, but not pouring out one drop of blood. For the prevention of fatal hæmorrhage, a ligature was applied, and subsequently amputation was performed at the shoulder-joint; on examining the artery below where the ligature was applied, the inner and middle coats were found to be retracted fully half an inch within the external or cellular coat, and the interval was filled with coagulated blood and cellular tissue in shreds. This blood Dr. Houston deemed to be perfectly fluid when it came under his observation first. The "pursed-up" extremities of the inner coats retracted within the cellular sheath, he believes to have been the efficient cause of the closure, so as to prevent a fatal effusion of blood. A preparation of the artery taken from the removed stump, slit up to show the condition of the coats, and a drawing of the parts in their recent state, were exhibited to the Section.

On the Treatment of External Aneurism by Pressure. By Prof. Harrison.

The author alluded to the danger incurred in the usual mode of treatment by ligature, notwithstanding all the improvements introduced by Hunter and Scarpa; it was most desirable that another less hazardous mode should be adopted. He wished to bring before the Section a case of successful treatment by pressure. This mode, he was aware, was not new, but he abstained from the attempt to arrest completely the circulation in the aneurismal sac, which attempt caused the very danger arising from ligature, namely, inflammation and sloughing; in the revival of this method, the object was by restraining the flow of blood through the sac, without interfering with the collateral circulation, to fill the sac gradually with a coagulation, and thus procure its obliteration, while the collateral circulation becoming enlarged by degrees, the limb will be supplied with its necessary quantity of blood. On this principle four cases had been successfully treated this year in Dublin, the last of which having been under his care, he laid it before the Section. The learned Professor then detailed the case at length from the 9th of May, when it first came under treatment, to the 10th of August, when the disease appeared to be completely removed. The instrument at first used was that described by Dr. Bellingham in the 'Dublin Medical Journal.' The pressure was made in the groin (the case being one of popliteal aneurism), and kept applied for about an hour, at intervals, its degree being regulated by the patient himself. In the progress of the case the instrument was obliged to be changed, and one known by the name of L'Estrange's tourniquet was applied at a different point on the limb, but this becoming irksome, a modification of the Carpenter's clamp, suggested by the patient himself, was used, and continued until the aneurismal swelling subsided, and all pulsation had disappeared. The collateral circulation appeared well-established, and the motions of the limb were unimpeded and free from pain. Although the symptoms of the disease had disappeared, Prof. Harrison had recommended the instrument to be continued for some time.

On the Deleterious Effects of Œnanthe Crocata. *By* Dr. Pickells.

This plant, he observed, was known to be one of the virulent poisons of the indigenous British Flora, but was stated to be very rare in Great Britain by Dr. Smith, in the letter-press of 'Sowerby's Botany;' this was by no means true as regarded Ireland, particularly in Cork, and other southern countries, in which it grows in great abundance. Dr. Pickells collected nearly thirty cases of death by eating the root, the quantity in one instance not exceeding "the top of the finger;" he described the symptoms as exhibited by those cases,—insensibility, convulsions, locked jaw, delirium and insanity; and pointed out the proper mode of treating such cases, by detailing several which were cured by the exhibition of strong emetics, diffusible stimulants, enemata, &c. He concluded by making some observations on the poisons used by the ancients in judicial executions; he thought that this might have been the plant used to destroy Socrates, and not the *Conium maculatum* of modern botany, and from the symptom of insanity, he thought that this was the plant designated as the "insane root" by the poet. This plant Dr. Pickells stated to be equally injurious to black cattle and horses as to man; he believed there was no direct antidote known; melted butter was given in some of the cases which recovered, and is popularly deemed a preservative against its effects. The root is frequently used as a discutient external application to tumours, and many of the accidents have occurred by eating it when gathered for this purpose.

New Instrument for the Removal of Calculi.

Dr. Houston exhibited to the Section a very ingenious instrument, invented by Samuel M'Clean, Esq. of Dublin, for the removal of calculi after the operation of lithotomy by incision, when the calculus happens to be so large or so misshapen that the ordinary forceps would be inapplicable for its extraction. The instrument consists of a net attached to a circular spring, which admits, by an ingenious mechanism, of being pulled into and protruded from a straight, hollow, silver cylinder of about one-third of an inch in diameter. This cylinder is to be introduced into the bladder through the incision, and when there, the net is to be thrown over the calculus by means of the spring. The spring is then to be drawn again within the cylinder, and the whole —cylinder, net, and calculus—removed in the same direction.

Description of the Sound useful for the Detection of Small Calculi.
By Dr. Brook.

On the Circulation of the Blood in Acardiac Fœtuses. By Dr. Houston.

Dr. Young, Sir Astley Cooper, and Dr. Marshall Hall, held the opinion that the circulation in an acardiac fœtus was maintained by the action of the heart of the perfect fœtus which accompanies it in utero, but this opinion was disproved by the fact that such were not always found in twin cases, but occurred singly, as was proved by Blandin and others; but even omitting such cases, Dr. H. argued, from theoretical principles, that the efficient cause of the circulation must be the innate vital action of the capillaries; the existence of such a power, he contended, was shown in several instances in comparative anatomy: in the earth-worm, the leech, and in the rudimentary vessels of the chick in ovo. This was the power recognized by Alison under the term "vital attraction and repulsion."

On the treatment of Gangrene of the Lungs by Chloride of Lime. By John Popham, *M.B., one of the Physicians to the North Cork Infirmary.*

Dr. Popham made a communication to the Section, directing attention to the chloride of lime as a valuable remedy in this usually fatal disease. Gangrene of the lungs, the writer observes, though of extremely rare occurrence, yet in his opinion is more frequently met with in Ireland than in England; and he accounts for it by the epidemics of typhus fever, combined with pneumonia, which occasionally visit Ireland. In some very debilitated habits this dangerous complication terminates in gangrene of the lungs. These cases almost universally defy the power of medicine, and are complicated with such aggravated wretchedness, as almost to extinguish in the mind the inherent love of life. Of three of these cases that he witnessed, he detailed at large to the Section the symptoms during life, and the appearances after death, of one that came under his notice in Sir Patrick Dunn's Hospital, Dublin, in order to lay down the distinctive features presented by the disease. In a case of the kind lately occurring at the North Cork Infirmary, he was afforded an opportunity of giving his testimony to the very few instances on record where medicine was of any avail. The remedial agent used was the chloride of lime, lately recommended in putrid diseases as palliating, where it does not cure the symptoms, and proposed in this affection by Dr. Stokes of Dublin, and M. Andral of Paris, but hitherto unsupported by sufficient records of cases where it had been used. The patient to whom it was given in the Infirmary, was a case of neglected pneumonia. When admitted into the hospital, after an illness of six weeks, during which time he tried to continue his occupation, he presented the peculiar physiognomy of gangrene, the countenance, as Laennec describes it, of a leaden hue, without either physical energy or mental hope. The expectoration consisted chiefly of a dark grumous matter, mixed with disorganized shreds and clots of such a repulsive fœtor, that after a violent fit of coughing it was so diffusible that all the patients had to leave the ward. The usual remedies were at first tried, such as bark with acids, wine and opium, without altering the aspect of the disease. He was then placed on the internal use of the chloride of lime, and the improvement was most sudden and obvious. The appetite returned, the fœtor of the expectoration gradually ceased, the countenance brightened up again with hope, and he was able, after using the remedy for six weeks, to return to his duties.

The chloride of lime was given in solution; six drachms of the saturated solution were mixed with six ounces of mucilage, and a few drops of tincture of opium, of which one ounce was taken every third hour. The writer concludes by observing, that a remedy which can so greatly control the most intractable and repulsive symptoms of this disease, even though it should be ineffectual in the most advanced stages of it, is of value. In medicine, truly it may be said,—

Est aliquid prodire tenus, si non datur ultra.

For this object he laid it before the Medical Section of the British Association.

On Intestinal Obstruction. By J. F. Olliffe, *M.D., President of the Parisian Medical Society.*

He commenced by stating, that the principal object was to bring under the notice of the British Association the operation for artificial anus, which had been recently performed by Dr. Amussat of Paris, in cases where obstinate constipation had prevailed, and where, but for the timely interposition of surgical aid, fatal consequences must have ensued. He expressed it as his opinion, that in consequence of the innovation lately introduced in the treatment of intestinal obstruction, many cases before regarded as incurable would henceforward be brought to a successful termination. He added, that he was influenced in bringing forward the subject of intestinal obstruction solely by the desire to give more publicity, through the medium of the Transactions of the British Association, to the best means of arresting the progress of the disease under notice.

Having given an historical *résumé* of the operations which had been performed, with a view to give issue to the accumulated fæcal matter in the intestinal canal, and having passed successively in review those performed according to Lithé's proceeding; by Pillore, Dubois, Duret, Dessault, Fine, Freer, Pring, Miriel, Dupuytren, Reny, Velpeau, &c., the author proceeded to instance several cases which had occurred at different periods, from the time of Ruysh, in the seventeenth century, down to the present period; and as precepts to guide the practitioner in his treatment, he laid down the following propositions:—

1. In the great majority of cases, the cause of obstruction resides in the large intestines.

2. The lesion seldom occupies the cæcum, the colon ascendens, or the arch of the colon. It very generally affects the sigmoid flexure of the gut, the point of junction of the sigmoid flexure with the rectum, or the rectum itself.

3. The anatomical lesion is not so frequently cancerous as is supposed.

4. In many cases represented as volvulus, intussusception, iliac passion, &c., the obstinate and prolonged constipation proceeds from an organic stricture of the large intestines.

5. When all medical means, such as purgatives, &c., have been resorted to without avail, no time should be lost in giving issue to the accumulated fæces, by establishing an artificial anus.

6. Calliscus' operation, modified by Amussat, should be preferred to any other.

7. Mercury administered internally has never produced beneficial results.

8. In all cases of operation, the lesion of the peritoneum should, if possible, be avoided.

9. The operation is equally applicable to adults and new-born infants.

The author next described the topographical anatomy of the lumbar region, and showed that the colon may be opened in each lumbar space without wounding the peritoneum, this membrane, in its reflection from the gut to the abdominal parietes, leaving about one-third of the posterior surface of the intestines uncovered.

The indications of the operation were set down as follows:—

1. Sternal tympanitis, or accumulation of fæces in the large intestines, proceeding from an organic lesion of the intestinal coats, and producing a mechanical obstacle to the passage of fæcal matter.

2. Prolonged retention of the fæces, which determines their accumulation, without depending on organic lesion.

3. Schirrous or other malignant tumours of the large intestines. Here the treatment is of course but palliative, but its effect, in many cases, is the prolongation of life for years.

4. Imperforation of the anus, with absence of the lower part of the gut.

The modus operandi, as practised by Amussat, was next described.

The differential diagnosis of the maladies which cause intestinal obstruction was then sought to be established, and the author concluded by exhibiting to the Association several original drawings and diagrams illustrative of his subject: those drawings are to form part of a forthcoming work by Amussat.

Abstract of a paper on the proximate cause of death after the spontaneous introduction of Air into the Veins. By John E. Erichsen.

The writer having given at length the various theories intended to explain this accident, states his opinion of their being far from satisfactory or free from objections, and proceeds to take them up *seriatim*, and combat their several principles, adducing several experiments that he had made, on the result of which it was that he disputed the validity of the causes assigned. These fully proved that death does not ensue from any functional derangement in the heart from distentic or poisonous influence, as that organ carries on its action subsequent to that event. They also show that air seldom or never enters the vessels of the brain, consequently death cannot be attributed to congestion of the cerebral organs. The writer next gives a history of a new series of experiments which he performed, and from which he deduces the following conclusions:—

First, that the primary arrest of the circulation takes place in the capillaries of the lungs, or in the terminal branches of the pulmonary artery, in consequence of the right ventricle being unable to overcome the mechanical obstacles presented by the air bubbles in the vessels of these organs.

Second, that respiration and animal life cease in consequence of a deficient supply of arterial blood to the central organs of the nervous system. The author next proceeds to give the best means of preventing the spontaneous introduction of air into the veins, and when it does occur, the best line of treatment to be adopted: the former he considers to be effected by tightly bandaging the chest and abdomen, in operations where it is likely to occur. The rationale of this is obvious, as it is only in respiration that the air can enter, by keeping the breath as shallow as possible, the danger is considerably lessened or averted. In the latter he recommends compressing the veins, so as to prevent the further ingress of the air; this, with artificial inflation of the lungs by some other more remedial means, he considers sufficient to prevent a fatal termination.

On the Statistical Results of Amputation. By Mr. Cronin.

The peculiarities of about twenty cases, with the results and brief observations, were communicated from a Report drawn up in a tabular form. He said he brought the subject forward from the desire which now exists to have uniformity in the mode of keeping hospital reports, and the results of such reports, he believed, would be much more valuable if exhibited in a uniformly constructed table; as a specimen of such a table he communicated his cases.

On the Sudden Falling off of the Hair of the Head, Eyebrows and Eyelashes from Fright. By Dr. O'Connor.

The writer thought the infrequency of such cases a justification for bringing the present one before the notice of the British Association, not having been able to find on record any such striking example.

The case is as follows: Daniel McCarthy, the son of a farmer resident near Kinsale, aged 12 years, in perfect health, was seized at night with a sudden fit of screaming, which alarmed the entire family. He stated the cause of his terror to have been, that he dreamed two men were dragging him from the house to murder him. On the next day the hair began to fall off in great quantities, and before a fortnight he was completely bald, and not a hair remained on his eyebrows or eyelashes. He continues in this state still, though seven years have elapsed, and enjoys perfect health.

On a Rare Case of Midwifery which occurred in the Cork South District Lying-in Hospital in July 1843. *By* Dr. Wherland.

The leading peculiarities were, a case of twins: first child; feet and funis presentation; head arrested above the brim of the pelvis by head of second child occupying the cavity. Dr. Wherland applied forceps on head of second child and delivered it *first*, ALIVE AND WELL. First child was still-born; no effort on part of mother effected any good, the impaction being very great, the two heads mutually opposing one another; both children were of the usual size common to twins.

Statistical Returns of the North Cork Infirmary during a period of Five Years, from July 1838 *to June* 1843. *By* John Popham, *M.B., Trinity College, Dublin, one of the Physicians to the Infirmary.*

Abstract of Tables.

Total number of patients admitted during five years	4330	
Total number of deaths in the same time	272	
Patients admitted moribund—dying within twenty-four hours	27	
Proportion of deaths to number of patients, not deducting moribund cases		1 in $15\frac{5}{6}$
Total of patients admitted in winter months	1133	or 1 in $11\frac{5}{9}$
Total of deaths in same months	98	
Total of patients in the three spring months, viz. March, April, May	971	or 1 in $14\frac{1}{14}$
Total of deaths in same months	69	
Total of patients in the three summer months, June, July, August	1066	or 1 in $22\frac{2}{3}$
Total of deaths in same months	47	

Total of patients in three autumn months, viz. September, October, November	1160	or 1 in 20
Total of deaths in same months	58	

Greatest mortality in the month of January, being 1 in 10; February, 1 in 11; March, 1 in 12; December, 1 in 13.

Mean mortality in the month of May, 1 in 14; November, 1 in 16; April, 1 in 18; June, 1 in 19.

Least mortality in the month of July, 1 in 26; August, 1 in 26; October, 1 in 25; September, 1 in 19; showing the great influence of season in the termination of life. It is to be observed that the majority of deaths were in chronic diseases.

Of *medical* diseases, the most fatal were phthisis and dropsy; of phthisis there were 29 fatal cases, nearly $\frac{1}{9}$ of the whole.

Most fatal months for consumptive patients were January and May, equal, each 5; next were February, June, and December, each equal, viz. 4; March, July, and October, 2 each; April, 1 dead. No deaths from consumption in August, September, and November. The three winter months were half the whole amount of deaths from phthisis.

It is remarkable that the months of March and April, popularly considered the most trying to consumptive patients, were not so in this table; the patient however may feel their ungenial influence and sink rapidly after they have passed; hence probably the mild months of May and June were so fatal in this disease.

Peculiarity of age.—It occurred earlier in females than in males, and in advanced life later in males. Thus, three of the females were under 20, none over 40; none of the males were under 20, five were over 40. Liability to the disease in females lies very much within the limits of the period of reproduction. Of the twenty-nine cases, 16 were males, 13 females.

Dropsical diseases were among the most frequent and fatal.

Cases of ascites with disease of liver	15
Dropsy, with Bright's disease of kidney and anasarca	10
Hydrothorax and anasarca	11
Total	36

Of these, 21 were males, 15 females. Dropsy is not a disease of early life, 3 cases only under thirty years; 1 a girl of seventeen, with disease of kidney; 2 with enlarged spleen. Most of the cases of diseased liver were caused by the abuse of spirituous liquors and improper food. Ovarian dropsy is rare, but one case occurred.

Next class of diseases in the order of fatality involve inflammation of some part of the intestinal canal.

Cases of inflammation of stomach and small intestines	10
Diarrhœa	11
Dysentery	7
Total	28

Of these, 16 were females, 11 males; showing a greater liability in females to these diseases.

The cases of *diarrhœa* occurred generally in elderly persons, and were accompanied with general decay of the constitution. In ordinary cases it could often be traced to a noxious fish diet.

Dysentery, formerly so fatal in this city, has greatly declined of late years, only seven fatal cases occurring in the infirmary during five years. This is one of the diseases which improved civilization has banished. It was caused in particular localities by unwholesome water: at present there is no city provided with better water than Cork.

Next fatal disease is *chronic bronchitis*. Number of deaths 10.

Senile cough is one of the most frequent diseases met with, but it is very protracted, and generally merges into other diseases, being seldom fatal by itself.

Diseases of heart are not so common among the lower ranks in this as in other countries; but four cases are recorded in the registry where disease of the heart existed without being secondary to other diseases.

Of *surgical* diseases, most fatal were burns and scalds.

Total of deaths from burns	22

Of these, 12 occurred *at* or *before* the age of five years, and 5 between that and ten; showing the great fatality of these accidents in early life. One case was an adult, 2 between forty and fifty, and 2 between fifty-five and seventy.

Immediate cause of death in these cases.—1 from tetanus, 1 from gangrene, and 20 from the shock received by the system. The dependent condition of the Irish poor, requiring them so often to commit the charge of infants to children in their absence, is the chief cause of this accident. In 7 cases death occurred within twenty-four hours from the accident.

Amputations.—17 capital; 7 of leg; 5 of thigh; 3 of fore-arm; 1 of arm; 1 of shoulder-joint; minor amputations not included.

Diseases requiring amputation.—3 cases of compound fracture of the leg; 1 ditto of arm; 2 of hand followed by gangrene; 1 disunited fracture of humerus; 5 cases of white-swellings of knee and wrist; 1 case gangrene of both lower extremities after fever; 1 exostosis of tibia. Of these, 13 cases were successful; 4 were fatal; viz. 1 of leg, and 3 of thigh.

Causes of death.—In 1 case gangrene, in another a chain of abscesses up the limb; in 2, hectic fever with suppuration. The case of amputation at the shoulder-joint was dismissed cured in six weeks.

Fractures.—Total admitted, 277.

Fractures of *lower* extremities.—Leg 81; thigh 41; neck of thigh-bone 11; patella 6; parts of foot 6. Total 145.

Fractures of *upper* ditto.—Arm 32; fore-arm 7; olecranon 2; scapula 2; parts of hand 15. Total 58.

Fractures of *head.*—Cranium 26; orbit 1; jaw 5; nose 6.

Fractures of *trunk.*—Ribs 23; clavicle 11; sternum 1; vertebra 1. Total 74.

Deaths from fractures were 18; viz. compound fractures of lower extremities 5; compound fractures of patella 2; 1 case of fracture of cervical vertebræ, and 7 of skull; 3 cases of fracture of the ribs with wound of lungs.

In the three latter cases death occurred in 1 case within thirty-six hours, in the other after four and six days.

In the case of fractured vertebræ, death occurred after eighteen hours.

In fractures of the skull, death does not seem to come on in any ascertainable period; 1 case of fracture of base of the skull with rupture of blood-vessels lived nine hours; another twelve hours; while a boy, with a similar fracture and effusion, lived thirteen days; and a child of two and a half years, with depression, lived twenty days.

The next fatal disease was erysipelas; an epidemic of this complaint existed in 1838 and 1839; while this epidemic lasted, which was during a year and a half, 137 cases were treated in hospital, and 11 cases were fatal, or $\frac{1}{12\frac{1}{2}}$. During the following three years and a half 45 cases were treated, and 5 cases died, or $\frac{1}{9}$. Hence the disease was relatively less fatal when epidemic. This probably was owing to its continuing in the hospital when it had abated in the city, and also to its attacking the worst cases. As a secondary affection it was most fatal in wounds of scalp, ulcers of lower extremities, and syphilis.

Of the 182 cases treated, 88 were females, 94 males.

Of the deaths, 6 were females, 10 of the other sex. Age seemed to exercise considerable influence over it, as it spared children, but usually attacked persons of middle or advanced life; thus only 26 cases were *at* or *under* twenty years; 78 from twenty to forty; and 78 cases from forty to seventy. The number of males, in very early or very advanced life, was relatively greater than that of females, while the latter had the preponderance in middle life. Since the cholera, the epidemic of erysipelas has been the only severe disease of a migratory nature that has visited Cork; during its continuance, and subsequently, continued fever has been less frequent and of a mild type.

Diseases that were once frequent now extinct, viz. intermittent fever.

Diseases rarely met in Cork and its vicinity, viz. calculus of the bladder and bronchocele. Neighbourhood is limestone; lime is deposited in culinary vessels from the water.

Diseases rarely met with from moral reasons, viz. delirium tremens. Temperance has lately modified various diseases, accidents especially; in 1839, 71 cases of fracture were admitted; in 1842, only 39.

Suicide.—Three cases of attempted suicide occurred in five years, 2 of these were fatal, throat being deeply incised; one in which a quantity of arsenic was taken recovered. Suicide is a crime of rare occurrence among the Irish poor, as well from their strong religious feelings, as from the agricultural nature of their pursuits and habits. Suicide seldom exists among persons whose wants are few and easily gratified, and in whose minds hope is always predominant.

Cerebral diseases much less frequently occur among the poor than diseases of the lungs or abdomen. In these the brain is not so heavily taxed as with persons in the higher walks of life. Five deaths occurred in hospital from affections of the brain.

Diseases most common, are such as arise either from sudden vicissitudes of the weather, or food with little nutriment: they are rheumatism, bronchitis, chronic diseases of stomach, and diarrhœa.

On a peculiar case of Sterility. *By* Dr. M'Evers.

On the Tests for Arsenic. *By* Dr. Bevan.

He pointed out the difficulties and unsatisfactory results in the modes of detecting that poison hitherto used in medico-legal investigations; even Marsh's test, he said, failed in giving a quantitative result. In conclusion, he proposed a new method of testing, which, he said, had the advantage of extreme simplicity in its manipulation, and certainty in its result. Into a narrow glass bottle he introduced dilute nitric acid (1 part acid to 4 of water) until it was half-full; into this he introduced a clean copper rod, and on the surface of the acid he poured melted tallow, which, when concrete, formed a diaphragm between the immersed and free portions of the rod. On this diaphragm he poured the solution of arsenic, and within six hours metallic arsenic was deposited on the upper portion of the rod; this test will detect the $\frac{1}{100}$th of a grain. A zinc rod will give the result more rapidly.

STATISTICS.

Statistical Report of the Parish of St. Michael. *By* Major N. L. Beamish.

The parish of St. Michael comprehends the district generally known under the name of the "Peninsula of Blackrock," being bounded on the north and east sides by the river Lee, on the south by the tributary stream of Tramore, which forms with the confluence of the tide the "Douglas Channel," and on the west by the town parishes of St. Nicholas and St. Finn Barr, the former meeting it about one mile from the city of Cork. It contains 1929 acres, or three square miles and nine acres; the whole population in April 1843, was 2,630, consisting of 457 families, living in 413 houses; sixty-one houses are uninhabited, and nine are in progress of building. Of this population 2187 are Roman Catholics, and 443 Protestants, including Dissenters, being a proportion of nearly five to one in a district much inhabited by Protestant gentry. The Catholic males number 1042, females 1145; Protestant males 197, females 246; 800 males and 900 females are over fourteen years of age; 439 males, and 491 females are under that age; ninety families are living in one room to each family, 260 in two rooms, and 207 in three or more rooms to each family; the average number of persons to a bed is three. The whole number of the gentry is 372, leaving the number of the working classes 2258; of these 1125 are males, and 1133 are females, which may be thus classified:—

Males.—Carpenters, 15; masons, 14; slaters, 12; tailors, 10; shoemakers, 14; smiths, 9; coopers, 3; cabinet-makers, 2; gardeners, 32; farmers, 53; gingle-drivers, 13; lime-burners, 18; brickmakers, 56; fishermen, 111; male servants, 79; labourers, 212; aged and infirm, 46; children, 426.—Total males, 1125.

Females.—Employed as servants, in field work, &c., 372; children and aged and infirm, 453; unemployed, but able to work, 308.—Total females, 1133.

In the above enumeration are not included the inmates of the Ursuline Convent, numbering 50 nuns, 80 boarders, and 20 servants; Mr. Rudkin's academy, containing 26 Protestant males; and Miss Bergin's academy, containing 16 Protestant females.

One hundred and thirteen of the working classes hold land varying from a quarter of an acre to seven acres, at an average yearly rent of 3*l.* per acre, exclusive of poor rate and county rate; the former of which may be averaged at 1*s.* 10½*d.* and the latter at 5*s.* 10*d.* per acre annually. Those holding under leases are also subject to the payment of tithe, which averages 2*s.* per acre, but this is not now very strictly enforced from the small holder in this parish, the landlord being at present responsible to the minister.

The soil is generally excellent, and capable of bearing the finest wheat crops; the course of tillage pursued by the working farmer is potatoes and wheat alternately; the former being manured, but so indifferently, and the general preparation of the land being so imperfectly performed, that the potatoe crop seldom yields more than seven tons, or the wheat crop more than six barrels of twenty stone, or three and a half English quarters to the acre, being not more than two-thirds of the produce of the same description of land under a proper system of tillage. Great ignorance, or an indolent adherence to old habits, is exhibited in the application of the manure, which is often left for days exposed in small heaps to the action of the atmosphere, and consequently to the loss of its most fertilizing properties by evaporation. Many of the labouring classes hire small portions of manured land from the gentry for the purpose of speculating in early potatoes, which, if productive, and at the ordinary average price, yield them a fair profit. Such portions of land, varying from ¼ to 3 acres, let at the rate of 10*l.* to 12*l.* per acre, which, although apparently high, often yield a profit of 6*l.* to 8*l.* per acre. But of late years the produce of potatoe ground has been very uncertain, and when the crop fails, either the poor tenant becomes a severe loser, or fails to make good his agreement with the proprietor: generally the emergency is met by abatements on the part of the landlord.

The number of men and boys able to work, and dependent upon work for subsistence, is 653; of these 370 are employed, and 283 unemployed. A great portion of the latter subsist on the earnings of some member of the family who is employed; others support themselves in a temporary manner by pledging or selling part of their effects, and others on the alms of the benevolent. The workhouse is the last resource, and although at the present moment 283 males, and 308 females, or *more than one-fourth of the working population*, are without the means of earning their livelihood, only three persons belonging to the parish are in the Cork Union Workhouse.

Wages.—Tradesmen's wages average 20*s.* per week. Labouring men receive 5*s.*10*d.*; women 3*s.*, and children 2*s.*; but many able-bodied men work for 5*s.* per week. For particular kinds of labour, such as quarrying, the wages are 7*s.* per week, and lime-burners receive 10*s.*, in consideration of being employed by night. From the superabundance of labour, wages do not, as formerly, rise in time of harvest, and good reapers can be had at the present moment at the ordinary average of 1*s.* per day.

Food, Clothing, &c.—The food of the poorest labourer consists of potatoes and milk, or potatoes and salt fish, the cost of which is about 9½*d.* per head per week, or 4*s.* 8*d.* per week for a family of six. A considerable number, however, namely, 1900, or more than five-sixths of the whole working population, use bread and meat occasionally: 1200, or more than one-half, once a week; and 700 twice a week. The average cost of food of the whole is 1*s.* 7*d.* per head per week, or 9*s.* 6*d.* per week for a family of six persons. The precarious condition of the fishermen is much to be deplored. According to a late act of parliament, they are prevented from fishing nearly one-half the year, and are often unsuccessful at other periods; they can consequently seldom put by anything to meet emergencies, and only three Blackrock fishermen have deposits (averaging 7*l.* each) in the Savings' Bank.

The cost of clothing annually is 18*s.* per head for a family of six; of coal 9*d.* per week for the same number; 1200 men and 800 women, or nearly nine-tenths of the working population, wear shoes and stockings; 320 have one or more pigs; 290 out of the 413 inhabited houses have pigsties; 230 only are furnished with privies, and the want of sewers, drains, water-shoots, and appropriate means for carrying away dirt and drainage from the houses of the labouring poor, are great impediments to their cleanliness. One of their greatest wants is that of wholesome water, as well for drinking as domestic purposes. There are only two public pumps, and these of hard water, about a mile apart, in the parish, but the water in one of them is so indifferent in quality as at times to be scarcely available for any domestic purpose, and the poor of this part of the parish are frequently obliged to provide themselves from a spring on the opposite bank of the river, at the distance of a mile, and at a great sacrifice of time and labour. 336 of the working classes receive assistance from the Cork Loan Bank, the average amount of each loan being 2*l.* 10*s.*; 38 have deposits in the Savings' Bank, averaging 10*l.* each; 300 have articles pledged, the amount of the united pledges of each individual averaging 2*l.*; 300 are in arrear of rent, at an average of 3*l.*; the whole amount of arrear is 900*l.*

Education.—190 Roman Catholic males attend the Blackrock National School; 165 Roman Catholic females attend Mrs. Murphy's Free School in Ballintemple; 181 Roman Catholic females attend the Convent Free School; 80 Roman Catholic males and females attend Mrs. Meade's school at Ballinlough; 37 Protestant males and females attend the Protestant Free School in Ballintemple; 26 Protestant males attend Mr. Rudkin's academy, Blackrock; 16 Protestant females attend Miss Bergin's academy, Blackrock.

Thus more than two-thirds of the children of the working classes, under 14 years of age, are in progress of education; 142 children pay for their education an average yearly sum of 3*l.* Of the 457 families into which the population is divided, and 87 of which alone are gentry, 435 families possess books, and 236 the Bible.

The moral condition of the working classes is extremely good; the only crimes committed are petty larcenies, and there are only two illegitimate children in the parish. Habits of intemperance, as regards intoxicating liquors, are little known, nor can this be attributed—unless, perhaps, by the influence of example—to the temperance or total abstinence system, for out of the whole working population of 2258, only 160 males and 60 females, or less than one-tenth, are members of the Temperance Society.

The large proportion of unemployed persons, particularly females, among the working classes of this district, is much to be deplored, and demands the attention of the benevolent. It may be mainly attributed to the large proportion of land under pasture in the demesnes of the gentry, which thus limits the field-work to little more than one-fourth of the area of the parish. There is no manufactory or public work, with the exception of small lime-works and brick-making, which employ but a very limited number of persons, the latter for only three months of the year.

On the Irish Silk Manufacture. By Dr. W. C. Taylor.

Dr. Taylor commenced by stating that the silk manufacture was introduced into Ireland by the French refugees, whom the revocation of the Edict of Nantes compelled to abandon their country. There are no certain records for fixing the precise date when silk weaving was commenced in Dublin, but it is generally believed that an ancestor of the present respected family of the Latouches commenced the weaving of tabinets or poplins and tabbareas in the liberties of Dublin about the year 1693. A great and fatal error was made by the new settlers in the very outset of their career; they adopted the principle of excluding the native Irish from the benefit of all the improved arts which they introduced, refusing to receive any of them as apprentices. The manufacture was consequently an exotic forcibly prevented from taking root in the soil, and deriving its support chiefly from a system of artificial patronage. So weak, indeed, was it, that, in 1733, the Irish manufacturers of silks and stuffs waited on Archbishop Boulter, who then virtually ruled Ireland, to obtain his influence in passing a law to prohibit the wearing of East India goods. In the year 1764, an act was passed to place the silk trade under the direction of the Dublin Society, as far as it extended within two miles and a half round the Castle, and the Society was empowered to make such laws and regulations for its management as they should deem necessary. It has been generally asserted, that under this system of management the silk trade attained a high degree of prosperity; in a paper furnished to the Hand-Loom Commissioners, it was stated that in the year 1775 there were 3400 looms in Dublin in full employment. That this return is grossly exaggerated will appear obvious from the following considerations. In the thirteen years, from 1752 to 1764, the average imports of silk into Ireland were

15,760 lb. Manufactured.
48,132 lb. Raw.
275 lb. Riband.

In the period, from 1765 to 1777, when the bounty system was in full operation, the following were found to be the averages—

18,200 lb. Manufactured.
45,990 lb. Raw.
1,060 lb. Riband.

That is, the imported fabrics had increased, while the raw material, to be worked up in Ireland, had diminished. This decline appears to have continued, and, in fact, we find, from Parliamentary documents, that in 1784 there were only 800 silk-weavers at work in Dublin, and that even these were not all in constant employment. In 1786 Parliament withdrew its support from the Society's silk warehouse. The trade was altogether suspended by the insurrection of 1798, and in 1800 it was deemed necessary to protect it by a duty of ten per cent. on the introduction of foreign and British silks. Soon after this, the silk manufacture began to be established in Lancashire and Cheshire, while in Ireland the trade was severely injured by combinations and trades-unions; several excellent workmen, unable to endure the arbitrary regulations established by these self-constituted bodies, removed to England, and, at this hour, there are more Irish than English engaged in silk-weaving at Macclesfield. In 1826 the protecting duties expired, and as the silk-weavers refused to modify their arbitrary laws so as to meet the altered circumstances of the times, the whole silk-weaving was destroyed as a branch of industry in Dublin. The poplin or tabinet manufacture, in which the weft is worsted, is always classed with the silk-trade in the returns made to the Irish Parliament. There are at present about 280 men and 70 women engaged in the poplin manufacture, assisted by 130 children employed in winding the bobbins or quills for the shuttles, at ages varying from 7 to 13 years. As the poplin manufacture is a very limited branch of industry, the Society of Operative Weavers has been able to maintain a fixed and uniform rate of prices for several years; and the master manufacturers generally concur in the system, because in an article of limited consumption, the use of which is exclusively confined to the wealthier classes of the community, it is of far greater importance to maintain the acknowledged superiority of the article than to produce it at a lower cost. The greatest improvements in the manufacture have resulted from the introduction of the Jacquard loom, and from a machine of recent invention for introducing a variety of colours in fancy brocading by a more effective process than that which was anciently employed. In what are called French poplins, cotton is very freely introduced, and though they are thus rendered much cheaper than the Irish, they are obviously inferior in richness and beauty, and they have been found still more so in permanence of colour and durability of material. The Irish poplins are highly esteemed abroad, and they are occasionally ordered in limited quantities for the principal continental courts, the United States of America, and the East and West Indies. Silk has not been thrown in Dublin since the year 1837; it is chiefly imported from England, and the consumption of organzine is estimated at about 18,000 lb. annually. There are about 240 poplin looms in Dublin, 20 velvet, and a few furniture tabbareas; so that the poplin may be regarded as the only branch of the silk-manufacture which has a healthy existence in Ireland. It has been already stated, that the high price of the fabric must always restrict the manufacture of poplin within what large mill-owners would consider exceedingly narrow limits, particularly as it is believed impossible to apply power successfully to this species of weaving.

On the Pauper Lunatics of Ireland, from materials supplied by the Earl of Devon. By Dr. W. C. TAYLOR.

Before the year 1817, a few cells in gaols and houses of industry were the only accommodation provided for lunatics; but in various parts of Ireland, and more especially in Kerry, certain secluded glens, called madmen's glens, were, by the tacit consent of the peasantry, set apart for the use of idiots and the insane. In 1817 district lunatic asylums were formed, and placed under the superintendence of government officers. A table was exhibited of the districts for which these hospitals were established, the population of these districts, and the number of patients admitted from the contributory counties; but as these give insufficient accommodation, cells for the insane are connected with several of the old houses of industry, where proper medical treatment of the insane, however, is utterly impossible. The author strongly condemned the system of confining lunatics in houses of industry, or, which is still worse, in gaols. By an act passed in the first session of the present reign, power is given to two justices of the peace, acting under the advice of a physician, to commit to gaol, or confine in a lunatic asylum, any one thought to be in a state of mind threatening mischief. It would seem that this statute has operated more widely than could have been anticipated by its framers. From the Sixteenth Report of the Inspectors-General of Prisons, it appears, that so recently as the year 1837, there were but thirty-seven insane patients confined in the gaols of Ireland. But in 1840 the number of lunatics confined in the gaols of Ireland had increased to 110; and within the last two years the number has doubled, there being now 240 lunatics and idiots in the gaols of Ireland. There are also 471 idiots and lunatics at present confined in sixty-nine workhouses.

At the opening of the Section on Tuesday, the Secretary informed the meeting that in consequence of a communication which had been received from his Excellency the Lord Lieutenant of Ireland, Capt. Larcom, R.E., would commence business by laying the Report of the Census of Ireland for 1841 on the table, and giving an account of the manner in which it had been taken. He then read a note from his Excellency's Secretary, which stated that his Excellency, desirous of promoting science, had allowed a copy of the unpublished Census of 1841 to be forwarded to the Association.

Capt. Larcom said, that he was appointed in 1841 a Commissioner of the Census in Ireland, and as the publication of the Ordnance Memoirs was then suspended, he seized the opportunity of collecting statistical information. Under the head of social economy the commissioners included every matter of interest that bore on the state of the country and its inhabitants; and the result is, that the present census has more the aspect of a statistical document than returns of the kind have had before. Care has been taken to distinguish between natural families and the domestic groups formed of the former with associated inmates. The dwellings, too, have been carefully classified; and the people generally have been considered, not under the usual head of agriculturists and manufacturers, but under the three heads, workmen, master workmen, and employers. The chief results of the census are, in numbers, as follows:—The population of Ireland is 8,175,124, of whom 4,019,576 are males, and 4,155,548 females. These persons live in 1,472,739 social families, and are dwelling in 1,328,839 houses.

Of these persons	2,765,212 males 2,662,023 females	are unmarried.
	1,142,628 males 1,181,095 females	are married.
And	111,736 males 312,420 females	are widowed.

The education varies from the county of Antrim, in which there are twenty-one per cent. of males, and twenty-three per cent. of females who can neither read nor write, to the county of Mayo, in which there are seventy-three per cent. of males, and eighty-seven per cent. of females, in the like deplorable state of ignorance. The number of houses compared with the population, does not appear at first sight very disproportionate, but when the houses are divided into classes, according to their quality and the number of families they respectively accommodate, the result is, that nearly half the families of the rural population, and more than one-third of the civic population, are found to be living in the lowest state, viz. a cabin of a single room. In the next class, but little superior in comfort, are about the same proportion; and the number living in the better classes are but sixteen per cent. in the towns, and thirty per cent. in the civic districts. The tables of ages are much disturbed by the amount of emigration for the last twenty years; which amount of emigration is very uncertain, from the great number of Irish who sail from English ports, where, of course, no separate registry of them is kept; but from the best information attainable, it amounted, between 1821 and 1841, to 538,285; and 39,179 recruits for the army have been raised in Ireland during that time. It was necessary to inquire into these numbers, in order to account for the apparently small increase of the population during the last ten years, which is only five per cent., whereas during the former ten years it was stated to have been fourteen per cent. There are some grounds for supposing that it was not really so great as fourteen per cent. between 1821 and 1831, and when due allowances are made for emigration and other draughts on the Irish population, especially to more profitable labour in England than their own country afforded, the real increase between 1821 and 1831 appears to have been twelve per cent., though only five per cent. remained in Ireland on the 5th of June 1841. The number of persons of Irish birth dwelling in Great Britain is 419,256, being 1 in 54 of the population of these parts of the empire, while of the natives of Great Britain dwelling in Ireland there are but 30,137, or 1 in 271 of its population. It ought to be stated in connexion with education, that the number of children at school was, at the time the census was taken, 502,950 of both sexes. It is difficult to find any document with which to compare these numbers, as all the returns give the number of "children on the poll," instead of the number actually attending, and the only documents which even with this defect embrace the schools of the whole kingdom are the census of 1821—

Which gave	394,813
Return of 1824, Commission of Inquiry for general instruction...	509,150
Census of 1834, by Commission for religious and public instruction	681,000
Census of 1841	502,950

and of these the second and third are professedly of children on the poll. Thus the number in 1841 was only about one quarter of the children who were at that time between the ages of five and fifteen. It is true that this proportion is altogether very small, but as the time that the children of the humbler classes remain at school is very short, it is not impossible but that even with this small number at one time, all may, during some portion of the long period of ten years, be receiving elementary instruction.

On certain Public Conveyances established in Ireland. By Mr. Bianconi.

Up to the year 1815, the public accommodation for the conveyance of passengers in Ireland was confined to a few mail and day coaches on the great lines of road. From my peculiar position in the country, I had ample opportunities of reflecting on many things, and nothing struck me more forcibly than the great vacuum that existed in travelling accommodation between the different orders of society. The inconvenience felt for the want of a more extended means of intercourse, particularly from the interior of the country to the different market towns, gave great advantage to a few at the expense of the many, and above all, occasioned a great loss of time; for instance, a farmer living twenty or thirty miles from his market town, spent the day in riding to it, a second day doing his business, and a third day returning. In July 1815, I started a car for the conveyance of passengers from Clonmel to Cahir, which I subsequently extended to Tipperary and Limerick. At the end of the same year I started similar cars from Clonmel to Cashel and Thurles, and from Clonmel to Carrick and Waterford; and I have since extended this establishment so as to include the most isolated localities, namely, from Longford to Ballina and Bellmullet, which is 201 miles north-west of Dublin; from Athlone to Galway and Clifden, 183 miles due west of Dublin; from Limerick to Tralee and Cahirciveen, 233 miles south-west of Dublin; and numbering 110 vehicles, including mail coaches and different-sized cars, capable of carrying from four to twenty passengers each, and travelling eight to nine miles per hour, at an average fare of one penny farthing per mile for each passenger, and performing daily 3800 miles, passing through more than 140 stations for the change of horses; consuming 3000 to 4000 tons of hay, and from 30,000 to 40,000 barrels of oats annually; all of which are purchased in their respective localities. These vehicles do not travel on Sundays, unless such portions of them as are in connexion with the post-office or canals, for the following reasons: first, the Irish being a religious people will not travel on business on Sundays; and secondly, experience teaches me that I can work a horse eight miles per day for six days in the week, much better than I can six miles for seven days. The advantages derived by the country from this establishment are almost incalculable; for instance, the farmer who formerly rode and spent three days in making his market, can now do so in one for a few shillings, thereby saving two clear days, and the expense and use of his horse. The example of this institution has been generally followed, and cars innumerable leave the interior for the principal towns in the south of Ireland, which bring parties to and from markets at an enormous saving of time, and in many instances cheaper than they could walk it. This establishment has now been in existence twenty-eight years, travelling with its mails at all hours of the day and night, and never met any interruption in the performance of its arduous duties. Much surprise has often been expressed at the high order of men connected with it, and at its popularity; but parties thus expressing themselves forget to look at Irish society with sufficient grasp. For my part, I cannot better compare it than to a man emerging into convalescence from a serious attack of malignant fever, and requiring generous and nutritive diet in place of medical treatment. Thus I act with my drivers, who are taken from the lowest grade of the establishment, and who are progressively advanced according to their respective merits, as opportunity offers, and who know that nothing can deprive them of this reward, and a superannuated allowance of their full wages in old age, and under accident, unless their wilful and improper conduct; and as to its popularity, I never yet attempted to do an act of generosity or common justice, publicly or privately, that I was not repaid tenfold.

On the Statistics of the Parish of Kilmurry, a rural district in the Barony of West Muskerry, in the County of Cork, from materials supplied by the Rev. Wm. Keleher.

The paper was read by Dr. D. Bullen, and exhibited a striking improvement in the physical and moral condition of the people, arising chiefly from the temperance movement and the great advance made in education.

Mr. Biggs read a specimen of an inquiry into the sanatory condition of certain parts of the county of Cork.

Description of the Blackwater River. By Mr. O'Flanagan.

On the Infant Industrial Schools of Tuscany.
By Signor Enrico Mayer of Milan.

The first infant schools, or, as they are there called, asylums, established in Tuscany, were opened simultaneously in Leghorn and Pisa in 1833. A third was soon after opened in Florence, and the example then was generally followed. They are supported wholly by voluntary contributions, and consequently their increase soon reached its furthest limit. There are now twenty of those infant schools, with 2000 children. The annual expenditure comes to about 1*l.* sterling a child, house rent, servants' wages, teachers' salary, and soup, being all included. The management of these schools generally rests with committees of ladies, who take by turn the duty of inspection; the remarks written in the inspectors' book become the subject of deliberation at the monthly meetings of the committee. The infant asylums of Tuscany are intended for the poor, and are entirely gratuitous. They are generally divided into two classes, having each a separate room, and a separate mistress. The first class contains children from eighteen months or two years to four or five years old. The second class contains children from four or five to seven or eight. A play-ground is attached to every asylum, and the children perform easy gymnastic exercises, which, however, do not interfere with their own choice of amusements. The introduction of manual works in the infant asylums in Italy constitutes one of the chief differences between them and similar institutions in France or England, and experiments are now making to continue the habits of early industry thus acquired, by procuring some work in the primary schools. A committee of tradesmen and artisans forms part of the society for infant schools at Florence, and they are to provide the children with some easy work, and facilitate afterwards their being employed in the exercise of different arts and trades. Linear drawing and the rudiments of geometry and mechanics are taught in the superior classes, but confining the instruction to that which can be of use in the exercise of every mechanical profession, without taking any one particularly in view. It is anxiously desired that the manual work of the children should be of a nature to be carried on individually, so that the social element of family life should continue undisturbed among them, and the infant population should be preserved as long as possible from the infection of factories. *Instruction* is much less than *education* the object of these infant asylums; these are made as much as possible conducive to moral training, and this by the most simple and gentle means of a maternal guidance. In the school-room the children pass through a series of exercises calculated to develope their mental and bodily faculties without tiring them. They are never kept sitting for more than a quarter of an hour at a time. The religious instruction of the children is directed by the curate of the parish in which the asylum is established. The mistresses of the asylums keep a journal, in which the moral history of the institution can be said to be contained, and from which a number of most interesting facts have been extracted, elucidating the workings of human intelligence and human affection, at an age which has not until now been sufficiently studied by the moral philosopher. Though the Tuscan infant asylums are of so recent a date, yet their effects are already, and in a remarkable degree, perceptible. The improvement in the health of the children received in the Tuscan asylums is a most striking fact. The study of this fact on the part of our medical committees has led to most important observations, not only with respect to the infants themselves, but extended to their families, and indeed to the whole of the poor population of our towns, and to the various districts of the towns themselves. The cases of death in our asylums is between two and three per cent., whilst the general mortality of children between two and six is in Florence sixteen per cent. The same results have been observed in Lombardy, where infant asylums are more numerous than in Tuscany. A thorough reform of every system of education, going through every species of schools, will be necessary, in order to put them on a par with the high educational character of our infant schools. The moral results likewise are not confined to the infants themselves, but are extended to their families. A great proportion of the children received at the infant asylums in Florence are found to come from the Foundling Hospital; indeed out of 600 children, *four hundred* belong to that class. They are children whose parents were forced by extreme destitution to abandon them; but as soon as our infant asylums were known to exist, parental affection resumed its rights in the hearts of those hundreds of parents, and a dishonouring brand was wiped away from the head of those hundreds of children, who found again the joy of their family, and were restored to their name and their civil condition. In the three years anterior to the opening of the infant asylums, the average number of children taken out of the Foundling Hospital was 176; but in 1833, when the asylums were first established, the number withdrawn was 214, and in 1837 it increased to 404. Few facts more pregnant than this with important consequences have ever been brought to light in the moral statistics of any country. The author, in conclusion, pointed out the superior efficacy of the elevating and kindly treatment of men above the harsh and repressive. "Who," he observed, "has not seen in the bad direction of public instruction or in the mismanagement of public charities a necessity for the increase of coercive institutions, which yet prove insufficient for the repression of crime; and has not learned to conclude that there may be a system of instruction which teaches no virtue, a system of charity which relieves no misery, and a system of punishment which puts a stop to no crime?"

On the progress of the Willingdon Agricultural School. By Mrs. Gilbert.

On the connexion between Statistics and Political Economy. By Professor Lawson.

The Professor began with remarking, that statistics present nothing but a dull and barren show of figures, until united with the principles which belong to political economy. The former study bears to the latter the same relation which experimental philosophy bears to mathematics. Political economy, though a mixed science, yet has its abstract part, and the application of the principles thence derived to facts leads us on to new truths. Statistics afford at once the materials and the test of political economy. The Professor then adduced an example of the way in which statistics frequently correct political economy. In Edinburgh, the proportion of marriages to the whole population is 1 in 136. In Leith, however, where the population is of much humbler grade, the proportion is 1 in 110. Again, in Perth, there is 1 marriage to 159 inhabitants; while in Dundee, which is a much poorer place, there is 1 in 111 inhabitants. Thus statistics prove that poverty is not a check on marriage, though political economists have always assumed that it is. We find another example in the doctrine of profits and wages, which Mr. Ricardo, followed by other political economists, held to be antagonistic, the increase of wages diminishing profits, and *vice versâ*; whereas Mr. Senior, on looking to facts, found that wages and profits usually rise and fall together. Mr. Ricardo's error, in this instance, is traceable to ambiguity of expression. While statistics afford materials and a test to political economy, the latter points out the proper object of statistical inquiries, and draws conclusions from their results.

Contributions to Academical Statistics, Oxford. By Professor Powell.

The following details refer solely to the first examination, called 'Responsions,' which takes place at the end of the first year of academical residence, and the passing of which is an indispensable preliminary for becoming afterwards a candidate for a degree, that is, in general, for continuing in the University. The column of matriculations is taken from the author's communications in the Reports of the British Association for 1839 and 1842. The number of candidates being in general greater than that of the matriculations, arises from the circumstance of many offering themselves a second, or even a third time, after failure or withdrawal on a previous occasion. The mean results may show generally the proportion of those who either failing or withdrawing at this examination, do not go through more than the first portion of their academical course. But no exact proportion can be assigned, owing to the circumstance just mentioned.

Year.	Matriculated.	Candidates for Responsions.	Passed.	Failed.	Withdrawn.
1832	377	415	308	51	56
1833	384	420	325	42	53
1834	360	379	307	29	43
1835	369	395	292	45	58
1836	369	420	311	56	53
1837	421	431	295	73	63
1838	393	489	336	107	46
1839	404	483	375	70	38
1840	396	408	326	53	29
1841	441	412	338	40	34
Mean ...	391	425	321	57	47

On a natural Relation between the Season of Death and the Anniversary of the Season of Birth, which varies with each Month of Birth; and on a similarily varying tendency to Death in the Anniversary of the Natal Month. By Joseph Peel Catlow.

The fundamental data of this communication are the months of birth and death respectively of 4743 individuals, collected *indiscriminately*, from general and particular biography, and other authentic sources, with a range of time from the sixteenth to the nineteenth century inclusive; the average duration of life being 51 years 3 months 18 days.

1. The monthly births and the monthly deaths respectively, throughout the year, differ inconsiderably in comparison with the quota furnished severally by the former to the latter. Thus, the greatest difference between the monthly births is only 2·57 per cent., and the greatest difference between the monthly deaths is only 2· per cent.; the greatest number of births being in February, and the least in July; the latter month also furnishing the smallest number of deaths, and April the largest. On the other hand, the greatest difference between the quota furnished *severally* by the

monthly births to the monthly deaths is 7·6 per cent., and the least difference 2·9 per cent. of the respective number of births; thus, while 12·4 of the January-born die in April, only 4·8 per cent. die in June; and again, while this small proportion of the January births is furnished to the mortality of June, this month is fatal to 12·3 per cent. of the June births.

2. Of the grand total of births throughout the year, 467, that is, 71·75, or 18·15 per cent., above $\frac{1}{12}$th, or the monthly average, die in the anniversary of the natal month, and 4·2 per cent. above the average in the anniversary of the *post-natal* month; while, on the other hand, the mortality in the two months which immediately precede the anniversary of the natal-month is 5·1 per cent. below the average.

3. The aggregate mortality of all births in the *natal quarter*, that is, in the three months of which the natal anniversary is the mean, is 1270; that is, 84·25, or 7·1 per cent. above $\frac{1}{4}$th, or the quarterly average; the only exception being for July births; the mortality of which in this quarter is 4· per cent. deficient.

4. The mortality in the anniversary of the natal month varies as follows, for each month of birth:—January, 35·17 per cent. +; February, 8·6 +; March, 24·4 +; April, 20·16 +; May, 31·+; June, 52·+; July, 20·+; August, 19·6 +; September, 12·3 –; October, 12·+; November, 2·39 –; December, 10·9 +.

5. The difference of mortality in the same month is very apparent on comparing its respective amounts when the month is successively one of the months of the *natal quarter*. Thus, *e.g.* the mortality of May is 31· per cent. + for May births, while it is 4·1 per cent. – for June births, and 20· per cent. – for April births. Again, the mortality of June is 52· per cent. + for June births, while it is 34·8 per cent. – for July births, and 26·8 per cent. — for May births. The mortality of July is variously below the average for all but July births, but the least deficient for August births.

On the Effect of Light as a part of Vital Statistics. By R. Dowden.

On the Heat and Warmth of Cottages. By R. Dowden.

Abstract of the Report of the French Minister of Public Instruction on the Higher Schools of France. By J. Heywood, *F.R.S.*

On the Statistics of Lunacy, with special relation to the Asylum in Cork. By Dr. Osborne.

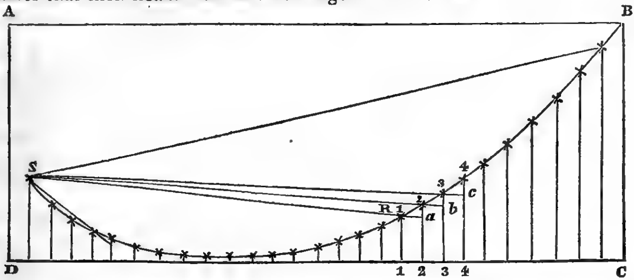
On the present Infecting and Demoralizing State of the Lodging-houses for the travelling poor in the towns and villages of England. By the late W. Leatham.

MECHANICAL SCIENCE.

On the Application of our Knowledge of the Laws of Sound to the Construction of Buildings. By Mr. Scott Russell.

The object of this paper was twofold—first, to apply our knowledge of the *known laws* of sound to the phænomena of speaking and hearing in a given building; and secondly, to develope certain *laws of sound recently discovered,* and not generally known; and to show their application to the same practical purposes. Part I. of the paper contained the application of the *known laws* of sound to the construction of buildings. The author prefaced this part of the paper by describing a form of building which had been found to be perfectly adapted to the purpose of seeing and hearing with distinctness and comfort. This arrangement of buildings had been described by him in a paper communicated to the Royal Society of Arts of Scotland some years ago, but had not been actually constructed on a large scale until lately, when a young architect, Mr. Cousins, of Edinburgh, having been employed to construct some large buildings, and alighting on this paper, adopted its principles.

Buildings were now erected on this principle, and contained from fifteen hundred to three thousand people, whom they accommodated without difficulty, and with perfect comfort both to speaker and hearer. He had little doubt, from experiments he had recently made, that so many as ten thousand people might be so arranged as to hear with ease and comfort a good speaker. Mr. Scott Russell's principle of construction is to place the speaker in the focus of a curve, which he calls the curve of equal hearing, or the isacoustic curve; and to place the seats of the auditors in such a manner that their heads shall all be arranged in this curve.



Let A B C D represent the vertical section of a building for public speaking, S the height of the speaker on his platform, D C the floor of the building: then, for the purpose that all the auditors should hear and see equally well, they should be placed on the line S R B of the acoustic curve. This curve is constructed in the following manner: D C is first divided into equal parts, to represent the usual breadth of a sitting, and vertical lines are drawn through these points. R being the place of the auditor 1; the place of auditor 2 behind him is assigned thus—join S R, and produce it to *a*—from *a* upwards set off $a\ 2 = 9$ inches, and 2 is the proper height of the next spectator. Then join S 2, produce it to *b*, and set off $b\ 3 = 9$ inches, and 3 is the place of the third spectator; and so on for the place of every spectator. Such was the vertical section of the building. The horizontal section was either circular or polygonal, having the speaker at the centre. This form had been found perfectly successful in affording the highest degree of comfort both to hearer and speaker; therefore he submitted it with confidence to the Section, as a practical and established principle, more than as a mere theoretical speculation.

He next entered into an analysis of the nature and causes of the evils which are experienced in public buildings of a large size and of the usual forms—in so far as these may be deduced from the received laws of sound. These he classed as follows. First, evils arising from reflexion of sounds. Second, evils arising from spontaneous oscillation, and the independent key-note of the building. In considering this branch of the subject, an explanation was attempted of the fact, that buildings have a key-note and pitch; and a rule for finding that pitch, practically and theoretically, was adduced. Third, evils arising from interferences of sound, owing to the disproportions and forms of buildings. These evils were all to be remedied by the adoption of the form given in the paper; and, on that construction, he had satisfied himself, that five, ten, or even twelve thousand people might be so arranged as to hear a single voice easily and comfortably. The second part of the paper examined certain phænomena in sound, with which we had not formerly been acquainted. Our knowledge of the laws of sound rested hitherto on an hypothesis, that the phænomena of sound in the air were analogous to the phænomena of water, when disturbed by dropping a stone on the surface of a smooth lake. In this case it is well known that the water propagates waves round the point of disturbance in all directions, and that these diffuse themselves in concentric rings over the whole surface. In like manner it was taken for granted, that the sound-waves, produced by a sonorous body, are of a similar nature, and the laws of sound had been deduced from this hypothesis. These laws were, however, imperfect and erroneous. Sound did not resemble these waves; therefore analogies deduced from such waves were erroneous. These waves of water are denominated by Mr. Russell, waves of the second order. But there is another kind of wave, the wave of the first order, to which the sound-wave bears a remarkable analogy. This wave had been examined in another place (in Section A.), and the properties of this order of wave enable us to solve many difficulties in the phænomena of sound. The common water-waves of the surface of a smooth lake had this property, that they were transmitted with *various velocities*, according to the circumstances producing the wave; but this was not so in the case of the sound-wave, the French Academicians having successfully established, that the velocities of sounds of different intensity and pitch are all transmitted in a fluid in a given condition, with precisely equal velocities: now the chief peculiarity of the sound-wave is this *constant of velocity*, independent of the conditions of the impelling cause. Another circumstance, serving to identify the sound-wave with the wave of the first order, is the similar characters of the formulæ expressing this velocity, whereas the formula expressing the velocity of common water-waves is of a form essentially different. It has further been observed, that there exist in the sound-wave, and in the wave of the first order, in water, the same *polarity*, the same law of *diffusion*, the same phænomenon of non-reflexion, at certain angles, and the phænomenon of lateral accumulation. From these data the author went on to give new explanations of the theory of whispering galleries, echoes, the conveyance of sound to great distances across lakes, ice, and other smooth surfaces. He applied the principles thus adduced to the explanation of many evils of certain forms of building not hitherto understood, and proceeded to develope the rules and methods to be adopted for the remedies of those evils.

On the Construction of Luntley's Shadowless Gas-burners, and the shape of Glass Chimneys for Lamps. By Henry Dircks.

The object of the burner was to bring the gas issuing from the small orifices into direct contact with atmospheric air at the ordinary temperature. Mr. Dircks contended that the heating of the air previously to its combustion diminishes the brightness of the flame; because, while each volume of carburetted hydrogen gas requires ten volumes of atmospheric air for its perfect combustion, the expansion of the air by heat necessarily reduces the weight of oxygen contained in the same volume of air; and therefore, unless some means be adopted of increasing the supply of air, the oxygen would be deficient. Another alleged advantage of the burner arises from the small quantity of metal employed in its construction, and which greatly assists the heating of the gas preparatory to its flowing through the orifices. The peculiarity in the form of the glass chimney consists in having the upper end enlarged. The effect of this enlargement, Mr. Dircks said, was to open the top of the flame, to render its figure more cylindrical and increase its brightness.

On the Prevention of Smoke from Engine Boilers and other Furnaces. By Henry Dircks.

Mr. Dircks gave a summary description of the Argand furnace invented by Mr. C. W. Williams, of which he said no less than 200 had been put up for land engine furnaces, and that the plan was adopted on board twenty-three steamers. By a reference to large diagrams he distinguished the difference between the mode of admitting the air to these furnaces compared with any method previously practised; he stated that in general inventors had endeavoured to burn as large a quantity of fuel with as little air as possible, but that Mr. Williams had clearly shown the importance of admitting air to the impure gas issuing from the fuel in the furnace; and not only so, but likewise that that air so required must be admitted in the extremely minute form of small streams or jets, the mixture of the air and gas being then made with greater effect and dispatch. It was now, he said, important to show that this plan was attended with considerable economy, as the best means to ensure its adoption. This, in the first place, depended on scientific evidence obtained by a knowledge of the chemistry of combustion; in the second, it was proved by the evidence of the pyrometer of Mr. H. Houldsworth of Manchester, consisting of an iron rod 30 or 40 feet long passing through the furnace flue, and which, as it elongated by heat, and contracted by lowering the temperature, showed distinctly, by a lever pointing to a graduated scale, any increment of heat obtained by the combustion of the gas. This increase of temperature, he stated, was found in practice to attend the admission of the jets of air, and to decrease by shutting off all access of air to the diffusion apparatus: there is, therefore, in this arrangement one supply of air for the gas by the perforated air distributions, and another for the fuel on the grate by the ordinary mode of an open ash-pit. Mr. Dircks explained a drawing of an ingenious pyrometer 104 feet long, extending through the entire length of a chimney at the works of Messrs. Ellis and Noton, Engineers, Manchester, who had become so familiar with this instrument, being self-registering, that they could distinguish all the alternations of work and stoppages occurring at the furnace.

Mr. Dircks added some statements as to the advantage and practicability of increasing the evaporative power of the boiler itself, and a table founded on experiments of the relative calorific and commercial value of different sorts of coal and turf variously prepared for the furnace.

Description of a Furnace for Economizing Fuel and Preventing Smoke. By JOHN CHANTER.

The author exhibited drawings of the arrangements he employed for these purposes. It differs from Mr. Williams's in the two essential particulars of heating the air before it is admitted to the fire, and of giving a reciprocating motion to the fire-bars, for the purpose of freeing them from clinkers and ashes. The air is admitted into an air-chamber to be heated, and a "deflective arch," at the bottom of the boiler, turns the generated gases on to the hot fuel, supplied with its requisite portion of oxygen through the clear fire-bars.

Mr. J. Juckes exhibited the model of his Furnace for Burning Smoke, with fire-bars consisting of endless chains passing over rollers, which was explained at the last Manchester meeting.

On the Application of Water as a Moving Power. By MR. RYAN.

In principle, the machine described resembled Barker's mill.

On a New Oil for Lubricating Machinery. By J. I. HAWKINS.

Mr. Hawkins described a practice which has lately been adopted in some parts of the United States, of procuring oil and spermaceti from pigs. The pigs are driven into the woods to feed, and after some months they are brought back and fattened with Indian corn. The animals are then killed and boiled altogether, for the purpose of extracting all the lard, which is then converted into *stearine* and *elain*. The oil thus procured is of a remarkably fine quality, and well adapted for lubricating machinery.

Mr. Hawkins read a paper on the friction of water against water, as exemplified in the well-known experiment of emptying a vessel full of water by sending a jet of the fluid through it. This friction of the particles of fluid against each other caused the principal obstruction to the motion of ships through the water; and he conceived that it would be advantageous to grease the bottoms of ships to diminish the friction.

On the Formation of Concrete. By J. I. HAWKINS.

In this communication the author showed the importance of having the stones of the proper sizes, so that the smaller ones should as nearly as possible fill up the interstices of the larger. Where the sizes were properly adjusted, he found that one proportion of lime to twenty of shingle formed a stronger concrete than when larger proportions of lime were used. Some engineers are in the habit of using one of lime to six of shingle, and the proportions generally used are as one to eight. A specimen of concrete made in the proportions he recommended, and with shingle of proper sizes, was found after a short time to be stronger than an old Roman wall.

On the Marine Propeller invented about the year 1825 *by Mr. Jacob Perkins. By* John Isaac Hawkins, C.E.

This propeller is a species of screw, but distinguished from that called the Archimedean Screw by revolving in a large circumference, and therefore requiring only a few revolutions per minute to effect a due speed of the vessel, and consequently a moderate number of strokes per minute of the steam-engine; distinguished also by about a fourth part only of the diameter descending into the water.

It may be described as two sets of revolving oars or scullers, entering the water obliquely at the same time on opposite sides of the vessel, passing by each other at the middle, and receding from each other after passing the middle of the vessel, until they leave the water at the sides opposite to their respective entrances. The object of this opposite entrance and exit of the oars is to leave the rudder free from bias to either side, and thus to render the vessel easy to be steered. These contrary motions are effected by fixing a set of four or six oars on the end of a solid axle, upon which another set of four or six oars, affixed to a hollow axle, revolves in a contrary direction. Or the propeller may be said to be like two sets of windmill vanes, the solid axle of one revolving within the hollow axle of the other, the two sets of vanes moving in contrary directions; the axis of rotation lying parallel to and over the keel, at about half the radius above the water line, so that only the extreme half of the radius is submersed, the face of the vane having a variable obliquity, calculated to give the same degree of propulsive effect from every part, according to its distance from the centre of motion. The centre of rotation being out of the water offers no obstruction, like the middle part of the Archimedean screw propeller, which, being submersed, becomes a hindrance, the beneficial effect being only obtainable from the parts of the screw at a distance from the centre.

Mr. Hawkins exhibited and explained a drawing of a propeller having two sets of six oars each, supposed to extend across the stern of a vessel thirty feet in width, the ends of the oars descending seven feet and a half into the water, constituting a propulsive effect proportionate to the velocity of the oars, combined with the obliquity of their forces. The tips of the oars revolving in a circle of thirty feet diameter, the number of revolutions per minute will be but small compared with the Archimedean screw propeller; the necessary speed will therefore be easily obtained by ordinary gearing from a moderate number of strokes per minute of the engine. Soon after the date of the patent this propeller was placed to work over the stern of a canal boat, and driven by a very defective steam-engine. The circumference of the circle described by the tips of the oars was about 25 feet. The propulsive force was most strikingly effective, and was continued for a few miles, when a part of the steam-engine broke and terminated the experiment. It was witnessed, Mr. Hawkins said, to the best of his recollection, only by Mr. Perkins, by himself, by the engine-driver and by the stoker.

He therefore feels it his duty to make an effort to rescue from oblivion this, in his opinion, the best of all marine propellers, which has laid dormant now for eighteen years. The patent expired four years ago.

Mr. Booth described an apparatus for raising miners and minerals from the deep vertical shafts of mines. It consists of a revolving inclined plane, or endless screw-shaft. The threads of the screw are made to act on the peripheries of small wheels extending from the carriage in which the miners, &c. are placed. A rotatory motion is communicated to the shaft, and the carriage is raised or lowered according to the direction in which the screw is turned.

Mr. J. Taylor described an immense steam-engine, which is now constructing in Cornwall, for the purpose of draining the lake of Haarlem. The cylinder of this "mammoth" engine is twelve feet in diameter, with a twelve-feet stroke. Round this immense cylinder are arranged eleven pumps, each of them of sixty-three inches diameter, with a nine-feet stroke. The valve at the bottom of the cylinder is on the butterfly construction, which is not generally conceived to be well adapted for large engines.

Mr. J. Taylor described a simple Steam-engine Indicator, which had been invented by Mr. A. Rous, who was formerly a working engineer in Cornwall. It consists of a half-second pendulum, to which a pencil is fixed and pointed against a card. The card is attached to the beam of the engine, and as it moves perpendicularly the pencil on the pendulum marks on it waving lines, which are wide apart when the piston moves quickly, and closer together as the velocity of the piston decreases. The distances between the lines indicate the spaces moved through by the piston in half a second in different parts of the stroke.

Mr. Perry mentioned that he had received a letter from Dublin, announcing the complete success attending the opening of the Atmospheric Railway on the branch of the Kingstown and Dublin line. The length of the atmospheric rail was one mile and three quarters; and the average gradient 1 in 100. After forty strokes of the stationary engine the vacuum gauge stood at 17 inches; after 100 strokes it was at $21\frac{1}{10}$; and it was ultimately raised to 22. The carriages were filled with passengers, and they ascended the line at a speed of twenty-eight miles an hour. When the machinery had got into proper working order, it was expected that a speed of at least fifty miles an hour would be attained.

Mr. Bevan exhibited a model of a complicated kind of Paddle Wheel, intended to be so contrived that the floats should enter the water and come out of it perpendicularly. It was proposed to effect this by having the floats moveable and weighted, so as to keep them perpendicular by their own gravity.

A communication from Mr. L. Cooke, of Parsons-town, describing a Clock Movement of his invention, and a new mode of suspending the pendulum, was read by Mr. Taylor. In this contrivance the pendulum is detached from all parts of the clock movement, and is in contact only at the suspending needle points. The pendulum is made to vibrate in half-seconds, by which means the variations owing to expansion and contraction are greatly diminished, and that source of error is further corrected by a compensating mechanical pendulum.

Sir T. Deane explained the method adopted by his brother, Mr. A. Deane, to raise the *Innisfaile* steam-vessel, of 500 tons, which was sunk by striking against an anchor in the Cork river a few years ago. The ordinary methods of raising sunken ships having proved ineffectual, a coffer-dam was made round the vessel in the middle of the river, and pumped dry by means of eight or nine chain-pumps. The leak was ascertained by digging under the ship, and a cow-hide was nailed over it to keep it water-tight. The coffer-dam was removed as quickly as possible, when the *Innisfaile* again floated by her own buoyancy, and the steam having been got up, she was taken to Passage to undergo the necessary repairs. The whole cost was 400*l.*, and the work was done in the course of four tides.

Mr. J. E. Purser exhibited Life-Preservers of his invention, which are applicable in cases of fire and of shipwreck.—To show the value of this first invention, he descended from an upper window of the court house; and he tested the efficacy of the water-escape cork-jacket at Cove during the excursion on Thursday.

Mr. G. White communicated an account of Mr. Starkey's system of Filtration by sponge compressed $\frac{1}{10}$ to $\frac{1}{15}$ of its natural bulk.

The Rev. Mr. Scoresby described an apparatus for simplifying the illustration of trigonometrical operations, especially with reference to the purposes of education. It is called by the inventor a trigonometrical indicator.

On a Method of Ascertaining inaccessible Distances at Sea or Land. By Mr. P. Leahy.

On this plan two small telescopes are fixed at the greatest distance the vessel will admit of, and so as to form some multiple of ten feet. This distance forms the base line on which the calculations are to be made.

Description of a Process for preventing the deleterious effects of Dry Grinding. By J. P. GROLLET.

Mr. H. Henessy read a paper on a very simple apparatus for the purpose of determining the distance of objects. A moveable base line carries on it a small arc, by which the approximate determination of distances of 500 feet is easily effected.

Omitted in the Report for 1842.

On the Buoyant Floatwater. By Capt. A. W. SLEIGH. *Read at Manchester in* 1842.

Captain Sleigh stated the basis on which the buoyant sea-barrier which he has devised depends for its successful operation, is the fact that the agitation and drift of the sea is entirely superficial, and that the reaction, usually denominated the ground swell, caused by a current passing over an uneven bottom, is so extremely limited in its uppermost effect, that it cannot be detected when a hand lead is lowered within three feet of an irregular ground over which a tide passes rapidly (say five knots an hour).

On the Barometric Compensation of the Pendulum. By Dr. ROBINSON. (*Section* A.)*

At the Manchester Meeting of the Association Professor Bessel made a communication on the improvement of the astronomical clock, which, with other valuable matter, contained a proposal to compensate for the changes of rate produced by the varying density of the atmosphere. This appears in the Report of the Sectional Proceedings, and also at much greater length in No. 465 of the 'Astronomische Nachrichten.' At the time Professor Stevelly remarked, that I had not merely proposed but applied this compensation twelve years ago †; and I should not have reverted to it, but that I think my method possesses certain advantages over that proposed by the illustrious astronomer of Königsberg, which entitle it to the preference in practice. It was long believed to be demonstrated that the rate of a pendulum was influenced by the air's density only as far as it lessened the arc of vibration and diminished its gravity by buoyancy. The researches of Kater on the length of the second pendulum are all vitiated by this mistake, which was discovered by Bessel during a similar investigation, in which he found, by using balls of different specific gravities, that the received buoyancy correction is too small. As early as 1825, and without any knowledge of what Bessel was doing, I had ascertained the same fact by comparing the rates of my transit clock with the barometric indications; and Colonel Sabine gave the final proof of it by swinging the pendulum in a vacuum apparatus in the year 1829. The amount of it is far from inconsiderable; even with the mercurial pendulum of my transit clock, which weighs 21 pounds, and presents a very small surface, it is $0^{s}\cdot 36$ for an inch change of the barometer. Now the remedy for this is obvious. If we attach a barometer to the pendulum, its fall transfers a cylinder of mercury from a point near the axis of motion to a greater distance from it; the time of vibration may thus be made to increase by the same amount that it decreases in consequence of the diminished density of the air. In the expression of this increase, there are two disposable constants, the diameter of the tube and the distance of an extremity of the barometric column from the suspension of the pendulum. Two conditions may therefore be fulfilled. Bessel assumes as one, that the lower surface of the mercury shall be at the centre of oscillation; an arrangement which does not seem to possess any peculiar advantage, as he makes the compensation by giving an appropriate diameter to the tube. This however does not admit of adjustment, while the method adopted by me of shifting the barometric column makes it perfectly easy, and permits me to apply the other constant to correct the variation of arc produced by a change of resistance. It is ob-

* This paper as given on p. 17 is incomplete.

† Astronomical Memoirs, vol. v. Dependence of Clock's rate on Barometer.

vious that if the moment of inertia of the pendulum increase as the air's resistance lessens, the arc of vibration may be made permanent; and that this is the change produced by the descent of the mercury in the compensating tube. It is not easy in the ordinary work of an observatory, to determine the precise relation between the arc and the condensity; but by placing the clock *in vacuo*, as Bessel proposes (and as Sir James South has actually done for several years past), the effect of resistance can be determined exactly, and the *diameter* of the tube selected, which will nearly correct it. This is not mere speculation, for I have verified it by trial. The diameter which I selected for my tubes (0·1 inch) is not far from the truth. In the autumn of last year a fall of 1·6 inch produced *no appreciable change of arc.* The temperature, however, was then nearly stationary; but notwithstanding its changes during the interval from that time till my leaving Armagh, the arc has been between 1° 36′ and 1° 39′. Before the tubes were applied, the limits for the same period were 1° 42′ and 1° 51′. The changes in Bessel's own clock, though made by Kessel, a first-rate artist, were still greater, being from 1° 25′ to 1° 39′, an excess owing in part probably to the great severity of the German winter. From what I have seen of the vacuum apparatus used by Sabine or South, I cannot refrain from expressing a wish that the experiment were tried of mounting a transit clock permanently *in vacuo*: such a clock would have many advantages, besides its exemption from changes of barometric pressure.

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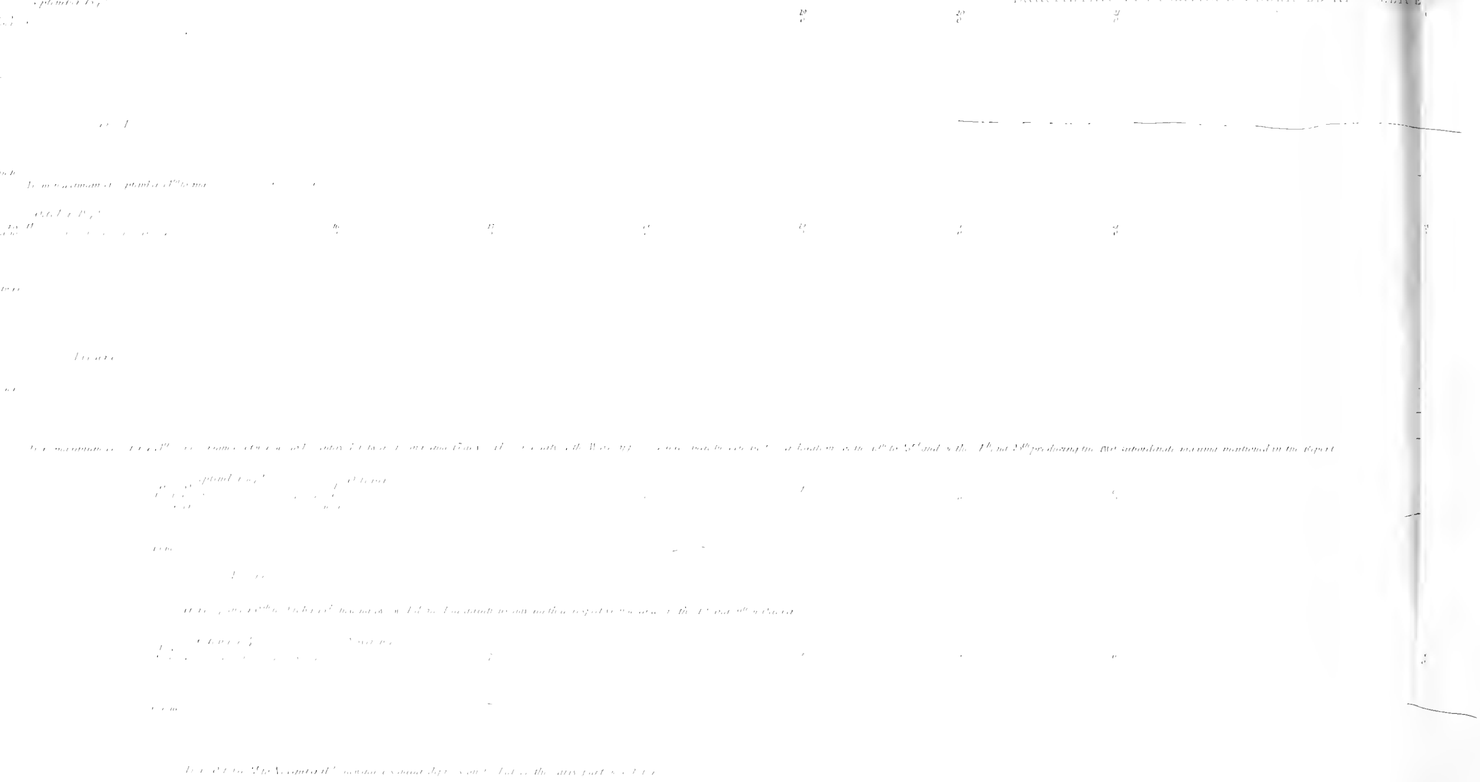

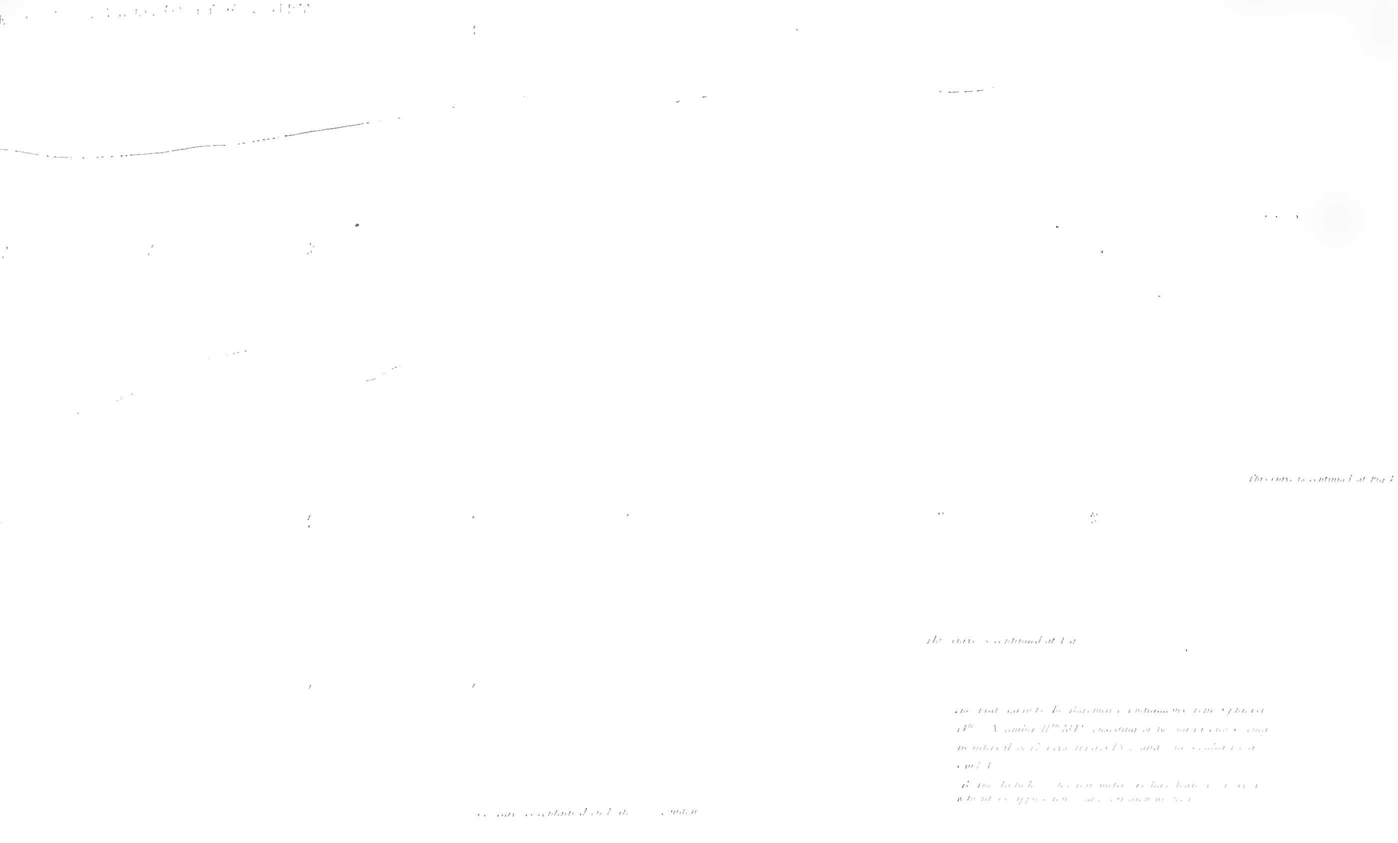

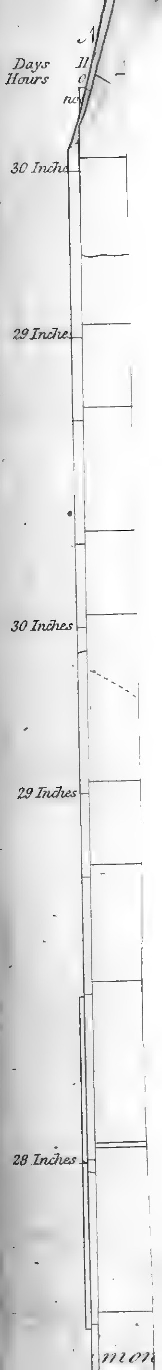
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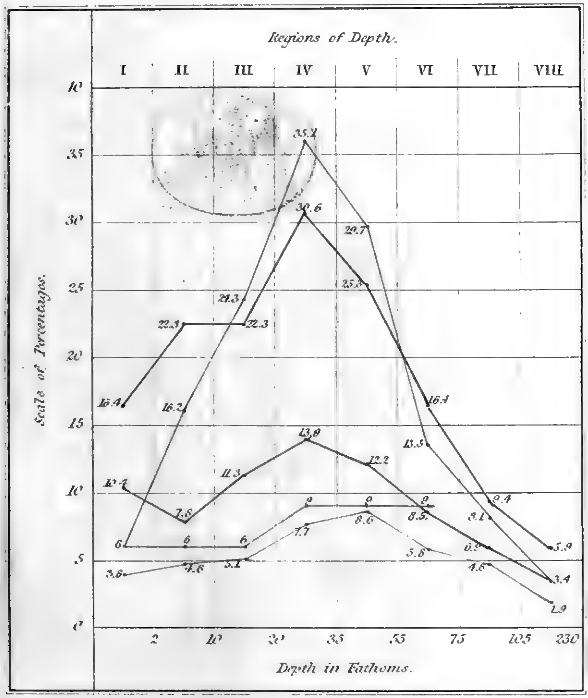
Diagram of Percentages of Northern Testacea in the Regions of Depth in the Egean.



Conchifera Dimyaria.
Conchifera Monomyaria.
Holostomatous Spiral Univalves
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