REPORT

OF THE

NINTH ANNUAL MEETING OF THE

SOUTH AFRICAN ASSOCIATION

FOR THE ADVANCEMENT OF SCIENCE.

BULAWAYO,
1911.

JULY 3—7

CAPE TOWN:
PUBLISHED BY THE ASSOCIATION.

1912.

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HONORARY PRESIDENT.

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CONSTITUTION

OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

[*As Amended at the Ninth Annual Meeting at Bulawayo, 1911.*]

I.—OBJECTS.

The objects of the Association are:—To give a stronger impulse and a more systematic direction to scientific enquiry; to promote the intercourse of societies and individuals interested in Science in different parts of South Africa; to obtain a more general attention to the objects of pure and applied Science, and the removal of any disadvantages of a public kind which may impede its progress.

II.—MEMBERSHIP.

(*a*) All persons interested in the objects of the Association are eligible for Membership.

(*b*) The Association shall consist of (a) Life Members, (b) Ordinary Members (both of whom shall be included under the term "Members"), and (c) Temporary Members, elected for a session, hereinafter called "Associates."

(*c*) Members and Associates shall be elected directly by the Council, but Associates may also be elected by Local Committees. Members may also be elected by a majority of the Members of Council resident in that centre at which the next ensuing session is to be held.

(*d*) The Council shall have the power, by a two-thirds vote, to remove the name of anyone whose Membership is no longer desirable in the interests of the Association.

III.—PRIVILEGES OF MEMBERS AND ASSOCIATES.

(*a*) Life Members shall be eligible for all offices of the Association, and shall receive gratuitously all ordinary publications issued by the Association.

(*b*) Ordinary Members shall be eligible for all offices of the Association, and shall receive *gratuitously* all ordinary publications issued by the Association during the year of their admission, and during the years in which they continue to pay, *without intermission*, their Annual Subscription.

(*c*) Associates are eligible to serve on the Reception Committee, but are not eligible to hold any other office, and they are not entitled to receive gratuitously the publications of the Association.

(*d*) Members may purchase from the Association (for the purpose of completing their sets) any of the Annual Reports of the Association, at a price to be fixed upon by the Council.

IV.—SUBSCRIPTIONS.

(*a*) Every Life Member shall pay, on admission as such, the sum of Ten Pounds.

(*b*) Ordinary Members shall pay, on election, an entrance fee of One Pound and an Annual Subscription of One Pound Subsequent Annual Subscriptions shall be payable on the first day of July in each year.

(*c*) An Ordinary Member may at any time become a Life Member by one payment of Ten Pounds in lieu of future Annual Subscriptions.

(*d*) The Subscription for Associates for a Session shall be Fifteen Shillings.

V.—MEETINGS.

The Association shall meet in Session Annually. The place of meeting shall be appointed by the Council as far in advance as possible, and the arrangements for it shall be entrusted to the Local Committee, in conjunction with the Council.

VI.—COUNCIL.

(*a*) The Management of the affairs of the Association shall be entrusted to a Council, five to form a quorum.

(*b*) The Council shall consist of the President, Retiring President, four Vice-Presidents, two General Secretaries and a General Treasurer, together with one Member of Council for every twenty Members of the Association.

(*c*) The President, Vice-Presidents, General Secretaries and General Treasurer shall be nominated at a meeting of Council not later than two months previous to the Annual Session, and shall be elected at the Annual General Meeting.

(*d*) Ordinary Members of Council to represent centres having more than 20 Members shall, not later than one month prior to the Annual Session of the Association, be elected by each such Centre, in the proportion of one representative for every twenty Members. The Annual General Meeting shall elect other Ordinary Members of Council, in number so as to give, together with the Members of Council already elected by the Centres, in all, one Member of Council for every twenty Members of the Association.

(*e*) The Council shall have the power to co-opt Members, not exceeding five in number, from among the Members of the Association resident in that Centre at which the next ensuing Session is to be held.

(*f*) In the event of a vacancy occurring in the Council, or among the Officers of the Association, in the intervals between the Annual Sessions, or in the event of the Annual Meeting leaving vacancies, the Council shall have the power to fill such vacancies.

(*g*) During any Session of the Association the Council shall meet at least twice, and the Council shall meet at least six times during the year, in addition to such Meetings as may be necessary during the Annual Session of the Association.

(*h*) The Council shall have the power to pay for the services of Assistant General Secretaries, for such clerical assistance as it may consider necessary, and for such assistance as may be needed for the publication of the Association Report or Journal.

(*i*) The Council shall have power to frame Bye-laws to facilitate the practical working of the Association, so long as these Bye-laws are not at variance with the Constitution.

VII.—LOCAL AND RECEPTION COMMITTEES.

(*a*) A Local Committee shall be constituted for the Centre at which the Annual Session is to be held, and shall consist of the Members of the Council resident in that Centre, with such other Members of the Association as the said Members of Council may elect.

(*b*) The Local Committee shall form a Reception Committee to assist in making arrangements for the reception and entertainment of visitors. Such Reception Committee may include persons not necessarily Members or Associates of the Association.*

(*c*) The Local Committee shall be responsible for all expenses in connection with the Annual Session of the Association.

VIII.—HEADQUARTERS.

The Headquarters of the Association shall be in Cape Town.

IX.—FINANCE.

(*a*) The Financial Year shall end on the 30th of June.

(*b*) All sums received for Life Subscriptions and for Entrance Fees shall be invested in the names of three Trustees appointed by the Council, and only the interest arising from such

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* The Reception Committee should make arrangements to provide :—

(1) A large hall for the delivery of the Presidential Address and evening lectures.

(2) A large room to be used as a Reception Room for members and others, at which all information regarding the Association can be obtained, and which shall have attached to it two Secretaries' Offices, a Writing Room for members and others, a Smoking Room, and Ladies' Room.

(3) Four rooms, each capable of accommodating about 30 or 40 people, to be used as Sectional Meeting Rooms, and, if possible, to have rooms attached, or in close proximity, for the purpose of holding meetings of Sectional Committees.

(4) Other requirements, such as office furniture, blackboards, window blinds to darken sectional meeting rooms for Lantern lectures, notice boards, etc.

investment shall be applied to the uses of the Association, except by resolution of a General Meeting.

(*c*) The Local Committee of the Centre in which the next ensuing Session is to be held shall have the power to expend money collected, or otherwise obtained in that Centre, other than the subscriptions of Members. Such disbursements shall be audited, and the financial statement and the surplus funds forwarded to the General Treasurer within one month after the Annual Session.

(*d*) All cheques shall be signed by the General Treasurer and a General Secretary, or by such other person or persons as may be authorised by the Council.

(*e*) Whenever the balance in the hands of the Treasurer shall exceed the sum requisite for the probable or current expenses of the Association, the Council shall invest the excess in the names of the Trustees.

(*f*) The whole of the accounts of the Association, *i.e.*, the local as well as the general accounts, shall be audited annually by an auditor appointed by the Council, and the balance-sheet shall be submitted to the Council at the first meeting thereafter, and be printed in the Annual Report of the Association.

X.—SECTIONS OF THE ASSOCIATION.

The Scientific Work of the Association shall be transacted under such sections as shall be constituted from time to time by the Council, and the constitution of such Sections shall be published in the Journal.

The Sections shall deal with the following Sciences and such others as the Council may add thereto from time to time:—Agriculture; Anthropology and Ethnology. Archæology; Architecture; Anatomy; Astronomy; Bacteriology; Botany; Chemistry; Education; Engineering; Eugenics; Geology and Surveying; Geography, Geology and Mineralogy; Irrigation; Mathematics; Mental Science; Meteorology; Philology; Physics; Physiology; Political Economy; Sanitary Science; Sociology; Statistics, Zoology.

XI.—RESEARCH COMMITTEES.

(*a*) Grants may be made by the Association to Committees or to individuals for the promotion of Scientific research.

(*b*) Every proposal for special research, or for a grant of money in aid of special research shall primarily be considered by the Sectional Committee dealing with the science specially concerned, and if such proposal be approved, shall be referred to the Council.

(*c*) A Sectional Committee may recommend to Council the appointment of a Research Committee, composed of Members of the Association, to conduct research or to administer a grant in aid of research.

(*d*) In recommending the appointment of Research Committees, the Sectional Committee shall specifically name all Members of such Committees; and one of them, who has notified his willingness to accept the office, shall be appointed to act as Secretary. The number of Members appointed to serve on a Research Committee shall be as small as is consistent with its efficient working.

(*e*) All recommendations adopted by Sectional Committees shall be forwarded without delay to the Council for consideration and decision.

(*f*) Research Committees shall be appointed for one year only, but if the work of a Research Committee cannot be completed in that year, application may be made, through a Sectional Committee, at the next Annual Session for re-appointment, with or without a grant—or a further grant—of money.

(*g*) Every Research Committee, and every individual, to whom a grant had been made, shall present to the following Annual Meeting a report of the progress which has been made, together with a statement of the sums which have been expended. Any balance shall be returned to the General Treasurer.

(*h*) In each Research Committee, the Secretary thereof shall be the only person entitled to call on the Treasurer for such portions of the sums granted as may from time to time be required.

XII.—SPECIAL COMMITTEES.

The Council shall have power to appoint Special Committees to deal with such subjects as it may approve, to draft regulations for any such Committees, and to vote money to assist the Committees in their work.

XIII.—SECTIONAL COMMITTEES.

(*a*) The Sectional Committees shall consist of a President, two Vice-Presidents, two or more Secretaries, and such other persons as the Council may consider necessary, who shall be elected by the Council. Of the Secretaries, one shall act as Recorder of the Section, and at least one shall be resident in the Centre where the Annual Session is to be held.

(*b*) From the time of their election, which shall take place as soon as possible after the Session of the Association, they shall form themselves into an organising Committee for the purpose of obtaining information upon Papers likely to be submitted to the Sections, and for the general furtherance of the work of the Sectional Committees.

(*c*) The Sectional Committees shall have power to add to their number from among the Members of the Association.

(*d*) The Committees of the several Sections shall determine the acceptance of Papers before the beginning of the Session, keeping the General Secretaries informed from time to time of their work. It is therefore desirable, in order to give an opportunity to the Committees of doing justice to the several communications, that each author should prepare an Abstract of his Paper, and he should send it, together with the original Paper, to the Secretary of the Session before which it is to be read, so that it may reach him at least a fortnight before the Session.

(*e*) Members may communicate to the Sections the Papers of non-members.

(*f*) The Author of any Paper is at liberty to reserve his right of property therein.

(*g*) The Sectional Committees shall meet not later than the first day of the Session in the Rooms of their respective Sections, and prepare the programme for their Sections and forward the same to the General Secretaries for publication.

(*h*) The Council cannot guarantee the insertion of any Report, Paper or Abstract in the Annual Volume unless it be handed to the Secretary before the conclusion of the Session.

(*i*) The Sectional Committees shall report to the Council what Reports, Papers or Abstracts it is thought advisable to print, but the final decision shall rest with the Council.

XIV.—ALTERATION TO RULES.

Any proposed alteration of the Rules—

a. Shall be intimated to the Council three months before the next Session of the Association.

b. Shall be duly considered by the Council and communicated by Circular to the Members of the Association for their consideration, and dealt with at the said Session of the Association.

XV.—VOTING.

In voting for Members of Council, or on questions connected with Alterations to Rules, absent Members may record their vote in writing.

RULES FOR THE AWARD OF MEDALS.

A. The South Africa Medal.

I.—Constitution of Committee.

(*a*) The Council of the South African Association for the Advancement of Science shall, annually and within three months after the close of the Annual Session, elect a Committee to be called "the South Africa Medal Committee" on which, as far as possible, every Section of the Association and each Province of South Africa shall have fair representation.

(*b*) This Committee shall consist of eight Members elected from amongst Council Members, together with four other Members, selected from amongst Members of the Association who are not on the Council.

(*c*) The Chairman of the Committee shall be appointed annually by the Council from amongst its Members.

(*d*) Any casual vacancy in the Committee shall be filled by the Council.

II.—DUTIES.

(*a*) The duties of the Committee shall be to administer the Income of the Fund and to award the Medal, raised in commemoration of the visit of the British Association to South Africa in 1905, in accordance with the resolution of its Council.

(*b*) This resolution reads as follows:—

(1) That, in accordance with the wishes of subscribers, the South Africa Medal Fund be invested in the names of the Trustees appointed by the South African Association for the Advancement of Science.

(2) That the Dies for the Medal be transferred to the Association, to which, in its corporate capacity, the administration of the Fund and the award of the Medal shall be, and is hereby, entrusted, under the conditions specified in the Report to the Medal Committee.

(*c*) The terms of conveyance are as follows:—

(1) That the Fund be devoted to the preparation of a Die for a Medal, to be struck in Bronze, $2\frac{1}{2}$ inches in diameter; and that the balance be invested and the annual income held in trust.

(2) That the Medal and income of the Fund be awarded by the South African Association for the Advancement of Science for achievement and promise in scientific research in South Africa.

(3) That, so far as circumstances admit, the award be made annually.

(*d*) The British Association has expressed a desire that the award shall be made only to those persons whose Scientific work is likely to be usefully continued by them in the future.

III.—AWARDS.

(*a*) Any individual engaged in Scientific research in South Africa shall be eligible to receive the award.

(*b*) The Medal and the available balance of one year's income from the Fund shall be awarded to one candidate only in each year (save in the case of joint research); to any candidate once only; and to no member of the Medal Committee.

(*c*) Nominations for the recipient of the award may be made by any member of the South African Association for the Advancement of Science, and shall be submitted to the Medal Committee not later than six months after the close of the Annual Session.

(*d*) The Medal Committee shall recommend the recipient of the award to the Council, provided the recommendation is carried by the vote of at least a majority of three-fourths of its Members, voting verbally or by letter, and submitted to the Council at least one month prior to the Annual Session for confirmation.

(*e*) The award shall be made by the full Council of the South African Association for the Advancement of Science after considering the recommendations of the Medal Committee, provided it is carried by the vote of a majority of its Members, given in writing or verbally.

(*f*) The Council shall have the right to withhold the award in any year, and to devote the funds rendered available thereby, in a subsequent award or awards, provided the stipulation contained in the second term of conveyance of the British Association is adhered to.

(*g*) No alteration shall be made in these Rules except under the condition specified in Rule XIV. of the Association's Constitution, reading:—

Any proposed alteration of the Rules—

a. Shall be intimated to the Council three months before the next Session of the Association.

b. Shall be duly considered by the Council, and be communicated by circular to the Members of the Association for their consideration, and dealt with at the said Session of the Association.

(*h*) Should a Member of the Medal Committee accept nomination for the Award or be absent from South Africa at any time within four months before the commencement of the ensuing Annual Session, he will *ipso facto* forfeit his seat on the Committee.

B. The Goold-Adams Medals.

(*a*) The Medals shall be awarded on the joint results of the Matriculation and University Senior Certificate Examinations of the University of the Cape of Good Hope.

(*b*) One Medal shall be awarded to the student who has taken the highest place in each of the seven Science subjects; (1) Physics, (2) Chemistry, (3) Elementary Physical Science, (4) Botany, (5) Zoology, (6) Elementary Natural Science, and (7) Mathematics, as set forth in the University Matriculation Examination and the University Senior Certificate Examination.

(*c*) The standard of marks shall be not less than 65 per cent. of the maximum.

(*d*) The Medals shall be struck in bronze.

(*e*) The first awards shall be made on the results of the 1910 examinations.

Table showing the Places and Dates of Meeting of the South African Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Foundation.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
Sir DAVID GILL, K.C.B., LL.D., F.R.S., F.R.S.E. CAPE TOWN, April 27, 1903.	S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Sir Charles Metcalfe, Bart, M.I.C.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S.
Sir CHARLES METCALFE, Bart., M.I.C.E. JOHANNESBURG, April 4, 1904.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	T. Reunert, M.I.C.E., M.I.M.E.
THEODORE REUNERT, M.I.C.E., M.I.M.E. JOHANNESBURG, August 28, 1905.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	W. Cullen.
GARDNER F. WILLIAMS, M.A. KIMBERLEY, July 9, 1906.	J. Burtt-Davy, F.L.S., F.R.G.S. James Hyslop, D.S.O., M.B., C.M. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.	W. M. Wallace, A.R.C.S., A.M.I.C.E.
JAMES HYSLOP, D.S.O., M.B., C.M. DURBAN, July 16, 1907.	J. Burtt-Davy, F.L.S., F.R.G.S. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S.	C. W. P. Douglas de Fenzi.
H.E. the Hon. Sir WALTER HELY-HUTCHINSON, G.C.M.G., LL.D. GRAHAMSTOWN, July 6, 1908.	Prof. J. C. Beattie, D.Sc., F.R.S.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S. Ernest Williams, A.M.I.C.E., M.I.M.M.	Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S. W. Hammond Tooke.

H.E. Sir HAMILTON GOOLD-ADAMS, G.C.M.G., C.B. BLOEMFONTEIN, September 27, 1909.	J. Burtt-Davy, F.L.S., F.R.G.S. Hugh Gunn, M.A. R. Marloth, M.A., Ph.D. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S.	Prof. G. Potts, M.Sc., Ph.D. A. Stead, B.Sc., F.C.S.
THOMAS MUIR, C.M.G., M.A., LL.D. F.R.S., F.R.S.E. CAPE TOWN, October 31, 1910.	W. Cullen Hugh Gunn, M.A. Prof. P. D. Hahn, M.A., Ph.D. J. M. P. Muirhead, F.S.S., F.R.S.E.	C. F. Juritz, M.A., D.Sc., F.I.C.
Professor PAUL DANIEL HAHN, M.A., Ph.D. BULAWAYO, July 3, 1911.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. C. W. Howard, B.A., F.E.S. A. J. C. Molyneux, F.G.S., F.R.G.S. A. Theiler, C.M.G., M.D.	G. N. Bromehead.

Presidents and Secretaries of the Sections of the Association.

Date and Place.	Presidents.	Secretaries.
SECTION A.—ASTRONOMY, CHEMISTRY, MATHEMATICS, METEOROLOGY AND PHYSICS.		
1903. Cape Town ..	Prof. P. D. Hahn, M.A., Ph.D.	Prof. L. Crawford.
1904. Johannesburg*	J. R. Williams, M.I.M.M., M.Amer.I.M.E.	W. Cullen, R. T. A. Innes.
1906. Kimberley ..	J. R. Sutton, M.A.	W. Gasson, A. H. J. Bourne.
1907. Natal†	E. N. Neville, F.R.S., F.R.A.S., F.C.S.	D. P. Reid, G. S. Bishop.
1908. Grahamstown	A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.	D. Williams, G. S. Bishop.
ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND GEOGRAPHY.		
1909. Bloemfontein	Prof. W. A. D. Rudge, M.A.	H. B. Austin, F. Masey.
1910. Cape Town‡	Prof. J. C. Beattie, D.Sc., F.R.S.E.	A. H. Reid, F. Flowers.
1911. Bulawayo ..	Rev. E. Goatz, S.J., M.A., F.R.A.S.	A. H. Reid, Rev. S. S. Dornan.
SECTION B.—ANTHROPOLOGY, ETHNOLOGY, BACTERIOLOGY, BOTANY, GEOGRAPHY, GEOLOGY, MINERALOGY AND ZOOLOGY.		
1903. Cape Town ..	R. Marloth, M.A., Ph.D.	Prof. A. Dendy.
1904. Johannesburg	G. S. Corstorphine, B.Sc., Ph.D., F.G.S.	Dr. W. C. C. Pakes, W. H. Jollyman.
1906. Kimberley ..	Thos. Quentrall, M.I.Mech.E., F.G.S.	C. E. Addams, H. Simpson.
CHEMISTRY, METALLURGY, MINERALOGY, ENGINEERING, MINING AND ARCHITECTURE.		
1907. Natal	C. W. Methven, M.I.C.E., F.R.S.E., F.R.I.B.A.	R. G. Kirkby, W. Paton.
1908. Grahamstown	Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.	Prof. G. E. Cory, R. W. Newman, J. Muller.
CHEMISTRY, BACTERIOLOGY, GEOLOGY, BOTANY, MINERALOGY, ZOOLOGY, AGRICULTURE, FORESTRY, SANITARY SCIENCE.		
1909. Bloemfontein	C. F. Juritz, M.A., D.Sc., F.I.C.	Dr. G. Potts, A. Stead.

* Metallurgy added in 1904.

† Geography and Geodesy transferred to Section A and Chemistry and Metallurgy to Section B, in 1907.

‡ Irrigation added in 1910 and Geography transferred to Section B.

Date and Place.	Presidents.	Secretaries.
CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.		
1910. Cape Town ..	A. W. Rogers, M.A., Sc.D., F.G.S.	J. G. Rose, G. F. Ayers.
1911. Bulawayo ..	A. J. C. Molyneux, F.G.S., F.R.G.S.	J G. Rose, G. N. Blackshaw.
SECTION C.—AGRICULTURE, ARCHITECTURE, ENGINEERING, GEODESY, SURVEYING, AND SANITARY SCIENCE.		
1903. Cape Town ..	Sir Chas. Metcalfe, Bart., M.I.C.E..	A. H. Reid.
1904. Johannesburg *	Lieut.-Colonel Sir Percy Girouard, K.C.M.G., D.S.O.	G. S. Burt Andrews, E. J. Laschinger.
1906. Kimberley ..	S. J. Jennings, C.E., M.Amer.I.M.E.. M.I.M.E.	D. W. Greatbatch, W. Newdigate.
BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE AND FORESTRY, PHYSIOLOGY, HYGIENE.		
1907. Natal	Lieut.-Colonel H. Watkins Pitchford, F.R.C.V.S.	W. A. Squire, A. M. Neilson, Dr. J. E. Duerden.
1908. Grahamstown	Prof. S. Schonland, M.A., Ph.D., F.L.S., C.M.Z.S.	Dr. J. Bruce Bays, W. Robertson, C. W. Mally, Dr. L. H. Gough.
1910. Cape Town †	Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S.	W. D. Severn, Dr. J W. B. Gunning.
1911. Bulawayo ..	F. Eyles, F.L.S., M.L.C.	W. T. Saxton, H. G. Mundy.
SECTION D.—ARCHAEOLOGY, EDUCATION, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.		
1903. Cape Town ..	Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.	Prof. H. E. S. Fremantle.
1904. Johannesburg	(Sir Percy Fitzpatrick, M.L.A.), E. B. Sargant, M.A. (Acting).	Howard Pim, J. Robinson.
1906. Kimberley ..	A. H. Watkins, M.D., M.R.C.S.	E. C. Lardner-Burke, E. W. Mowbray.
EDUCATION, PHILOLOGY, PSYCHOLOGY, HISTORY, ARCHAEOLOGY: ECONOMICS AND STATISTICS, SOCIOLOGY, ANTHROPOLOGY AND ETHNOLOGY.		
1907. Natal	R. D. Clark, M.A.	R. A. Gowthorpe, A. S. Langley, E. A. Belcher.

* Forestry added in 1904.
† Sanitary Science added in 1910.

Date and Place.	Presidents.	Secretaries.
EDUCATION, PHILOLOGY, PSYCHOLOGY, HISTORY AND ARCHAEOLOGY.		
1908. Grahamstown	E. G. Gane, M.A.	Prof. W. A. Macfadyen, W. D. Neilson.
ECONOMICS AND STATISTICS, SOCIOLOGY, ANTHROPOLOGY AND ETHNOLOGY.		
1908. Grahamstown	W. Hammond Tooke.	Prof. A. S. Kidd
ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.		
1909. Bloemfontein	Hugh Gunn, M.A.	G. C. Grant, Rev. W. A. Norton.
1910. Cape Town ..	Rev. W. Flint, D.D.	G. B. Kipps, W. E. C. Clarke.
1911. Bulawayo ..	G. Duthie, M.A., F.R.S.E.	G. B. Kipps, W. J. Shepherd.

EVENING DISCOURSES.

Date and Place.	Lecturer.	Subject of Discourse.
1903. Cape Town ..	Prof. W. S. Logeman, L.H.C., B.A.	The Ruins of Persepolis and how the Inscriptions were read.
1904. Johannesburg	H. S. Hele-Shaw, LL.D., F.R.S., M.I.C.E.	Road Locomotion — Present and Future.
1906. Kimberley ..	Prof. R. A. Lehfeldt, B.A., D.Sc.	The Electrical Aspect of Chemistry.
	W. C. C. Pakes, L.R.C.P., M.R.C.S., D.P.H., F.I.C.	The Immunisation against Disease of Micro-organic Origin.
1907. Maritzburg ..	R. T. A. Innes, F.R.A.S.	Some Recent Problems in Astronomy.
Durban	Prof. R. B. Young, M.A., B.Sc., F.R.S.E., F.G.S.	The Heroic Age of South African Geology.
1908. Grahamstown	Prof. G. E. Cory, M.A.	The History of the Eastern Province.
	A. Theiler, C.M.G., M.D.	Tropical and Sub-tropical Diseases of South Africa: their Causes and Propagation.
1909. Bloemfontein	C. F. Juritz, M.A., D.Sc., F.I.C.	Celestial Chemistry.
	W. Cullen.	Explosives: their Manufacture and Use.
Maseru	R. T. A. Innes, F.R.A.S.	Astronomy.
1910. Cape Town ..	Prof. H. Bohle, M.I.E.E.	The Conquest of the Air.
1911. Bulawayo ..	J. Brown, M.D., C.M., F.R.C.S., L.R.C.S.E.	Electoral Reform — Proportional Representation.
	W. H. Logeman, M.A.	The Gyroscope.

GENERAL MEETINGS AT BULAWAYO.

On *Monday, July* 3, at 4.30 p.m. Members attended an "At Home" held by Mr. and Mrs. Percy S. Inskipp at Government House.

At 8.15 p.m., the Association was officially welcomed by His Worship the Acting Mayor (Mr. A. Fraser) in the Hall of the Grand Hotel, after which Professor P. D. Hahn, M.A., Ph.D., took the chair as President, and delivered an address, for which see page 1. A vote of thanks was accorded to the President by acclamation, on the motion of Sir Joseph Vintcent, Kt., B.A., LL.B.

The President then presented the South Africa Medal and grant to Dr. L. Péringuey, F.E.S., F.Z.S. For the proceedings see page xxiii. This was followed by a reception given by the Local Members of the Association.

On *Tuesday, July* 4, at 9.30 a.m., Members of the Association proceeded on an excursion to the Matoppos, where Rhodes's grave, the Shangani Memorial and the Bushman Caves were visited.

At 8.15 p.m., in the Library Board Room, Dr. J. Brown, C.M., F.R.C.S., L.R.C.S.E., delivered a discourse on "Electoral Reform—Proportional Representation," His Worship the Acting Mayor presiding.

On *Wednesday, July* 5, at 2 p.m., Members of the Association visited the Khami Ruins under the conductorship of Mr. R. N. Hall, F.R.G.S.

At 8.15 p.m. Members were entertained at a Promenade Concert in the Central Park by the full regimental band of the Southern Rhodesia Volunteers, Western Division.

On *Thursday, July* 6, at 2 p.m., Members proceeded on excursions to Bushman's Haunt, Matjemehlope Kopjes, and the Old Nic Mine.

At 8.15 p.m., in the Library Hall, Mr. W. H. Logeman, M.A., delivered a discourse on "The Gyroscope," His Worship the Acting Mayor presiding.

On *Friday, July* 7, at 9.30 a.m., the Ninth Annual General Meeting was held in the Eveline School, for minutes of which see page xvii.

At 12.30 p.m. Members proceeded on an excursion to the Victoria Falls.

OFFICERS OF LOCAL AND SECTIONAL COMMITTEES, BULAWAYO, 1911.

LOCAL COMMITTEE.

Chairman, A. J. C. Molyneux, F.G.S., F.R.G.S.; *Local Secretary*, G. N. Bromehead; G. N. Blackshaw, B.Sc., F.C.S., F. P. Mennell, F.G.S., Sir Charles Metcalfe, Bart., M.I.C.E., H. U. Moffat, E. A. Nobbs, B.Sc., Ph.D., S. F. Townsend, C.E., Franklin White.

RECEPTION COMMITTEE.

Chairman, His Worship the Acting Mayor of Bulawayo (Alex. Fraser, Esq.); *Hon. Secretary*, G. N. Bromehead; A. H. Ackermann, R. Asermann, W. J. Atterbury, J. W. Ayling, R. Bannatyne, Rev. Father Barthelemy, Major Baxendale, F. R. Barnes, E. C. Baxter, Captain W. B. Bucknall, Geo. Carroll, Sir Charles Coghlan, M.L.C., J. Campbell Rogers, Rev. M. I. Cohen, B.A., Dr. W. G. Clark, C. Corner, W. Currie, C. Davis, Rev. S. S. Dornan, M.A., F.G.S., W. E. Dowsett, Capt. C. Duly, D.S.O., Dr. Eaton, C. R. Edmonds, M.R.C.V.S., A. S. Fletcher, P. Fletcher, R. A. Fletcher, Ven. Archdeacon Foster, A. M. Fraser, G. S. D. Forbes, C.M.G., D.S.O., M.L.C., H. W. Garbutt, Rev. Father Gardner, Rev. E. Goetz, S.J., F.R.A.S., J. Goldberg, Rev. C. E. Greenfield, R. N. Hall, F.R.G.S., Lieut.-Colonel Heyman, M.L.C., H. S. Hodges, Capt. A. G. Hendrie, E. A. Hull, P. S. Inskipp, W. W. Jenkins, P. L. Jenkins, G. Johnson, Major D. Judson, Capt. Jesser-Coope, A. G. Keith, L. Landau, Dr. Le Feuvre, R. A. Letts, J. Laughton, J. G. Macdonald, D. MacGillivray, Major MacGlashan, J. D. McKenzie, Major Macqueen, W. F. Miolee, G. Mitchell, M.L.C., R. E. Murray, Rev. Father Nicot, R. M. Nairn, I. Nicholson, Major Purcell, D.S.O., L. G. Puzey, H. A. Piper, S. Redrup, E. R. Ross, J. P. Sampson, A. W. Seccull, G. H. Sessel, J. Shiel, J. W. Sly, Rev. J. W. Stanlake, G. Stewart, C. J. Syme, Dr. E. H. Strong, L. Thomas, Dr. Vigne, D. Vincent, Sir Joseph Vintcent, B.A., LL.B., P. B. S. Wrey, C. F. de B. Winslow, A. D. Webb.

SECTIONAL COMMITTEES.

Section A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND IRRIGATION.

President, Rev. E. Goetz, S.J., M.A., F.R.A.S.; J. R. Sutton, M.A., Sc.D., A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E., E. N. Nevill, F.R.S., F.R.A.S., F.I.C., Sir Charles Metcalfe, Bart., M.I.C.E., Prof. W. A. D. Rudge, M.A., Prof. J. C. Beattie, D.Sc., F.R.S.E. (*ex-officio*); S. F. Townsend, C.E., W. G. R. Macmuldrow, R. A. Fletcher, D. MacGillivray; *Hon. Secretaries*, Arthur H. Reid, F.R.I.B.A. (*Recorder*), Rev. S. S. Dornan, M.A., F.G.S.

Section B.—CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.

President, A. J. C. Molyneux, F.G.S., F.R.G.S.; *Vice-President*, F. P. Mennell, F.G.S.; Prof. P. D. Hahn, Ph.D., M.A., G. S. Corstorphine, B.Sc., Ph.D., F.G.S., Prof. E. H. L. Schwarz, A.R.C.S., F.G.S., C. F. Juritz, M.A., D.Sc., F.I.C., A. W. Rogers, M.A., Sc.D., F.G.S. (*ex-officio*); Franklin White, H. B. Maufe, F.G.S., H. A. Brett, A. E. V. Zealley, F.G.S., A.R.C.S.; *Hon. Secretaries*, J. G. Rose, F.C.S., Cape Town (*Recorder*); G. N. Blackshaw, B.Sc., F.C.S.

Section C.—BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE, FORESTRY, PHYSIOLOGY, HYGIENE AND SANITARY SCIENCE.

President, F. Eyles, F.L.S., M.L.C.; R. Marloth, M.A., Ph.D., Lieut.-Colonel H. Watkins-Pitchford, F.R.C.V.S., Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S., Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S. (*ex-officio*), L. Péringuey, D.Sc., F.E.S., F.Z.S., R. Jack, F.E.S., L. E. W. Bevan, M.R.C.V.S.; *Hon. Secretaries*, W. T. Saxton, M.A., F.L.S. (*Recorder*), H. G. Mundy.

Section D.—ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.

President, G. Duthie, M.A., F.R.S.E.; *Vice-President*, R. N. Hall, F.R.G.S.; Dr. A. H. Watkins, M.R.C.S., E. G. Gane, M.A., W. Hammond Tooke, Hugh Gunn, M.A., Rev. W. Flint, D.D. (*ex-officio*), W. E. C. Clarke, M.A., Ven. Archdeacon Foster, M.A., Rev. S. S. Dornan, M.A., F.G.S., E. M. Foggin; *Hon. Secretaries*, G. B. Kipps, F.R.G.S. (*Recorder*), W. J. Shepherd.

PROCEEDINGS OF THE NINTH ANNUAL MEETING OF MEMBERS.

(Held in the Eveline School, Bulawayo, on Friday, July 7, 1911.)

Present: Professor P. D. Hahn, M.A., Ph.D. (President) in the chair; Dr. Moir, Dr. Péringuey, Professor R. F. A. Hoernlé, Professor W. S. Logeman, Professor T. P. Kent; Messrs. A. J. C. Molyneux, H. E. Wood, G. N. Blackshaw, F. Eyles, M.L.C., J. D. Stevens, F. P. Mennell, T. N. Leslie, E. Collins, W. T. Miolee, G. Duthie, Rev. S. S. Dornan, Mrs. E. Collins, Miss S. B. Leiter, Miss J. E. Minor and Mr. G. F. Britten (Assistant General Secretary).

Minutes.—The Minutes of the Eighth Annual General Meeting held on November 4, 1910, printed in the Report of the Cape Town Session, were confirmed.

Annual Report of Council.—The Annual Report of the Council having been suspended for three days previous to the meeting, was taken as read.

Mr. H. E. Wood (Johannesburg), moved to delete the second portion of paragraph 7 of the Report, and to substitute therefor, "Your Council trusts that they will be resumed in 1912." This was seconded by Dr. Moir (Johannesburg), and carried.

On the motion of Dr. Moir, seconded by Prof. Hoernlé, the Report as amended was adopted (see page xx).

Report of the Hon. Treasurer and Statement of Accounts for 1910-1911.—Owing to the proximity of the Annual Meeting to the close of the financial year, and on account of the absence in England of the Honorary Treasurer, it was found impracticable to submit a financial statement and report.

Amendment of Constitution.—Mr. T. N. Leslie moved: "That the amendments to the Constitution as proposed by Council having been duly circulated, the Constitution as amended be adopted." This was seconded by Prof. Hoernlé and carried.

Election of Council for 1911-1912.—The following officers were elected for 1911-1912:—

President, Dr. A. Theiler, C.M.G., M.D.; Vice-Presidents, Prof. L. Crawford, M.A., D.Sc., F.R.S.E., Dr. J. Moir, M.A., F.C.S., Mr. A. J. C. Molyneux, F.G.S., and Mr. W. Arnott; General Secretaries, Mr. R. T. A. Innes, F.R.A.S., F.R.S.E., Dr. C. F. Juritz, M.A., F.I.C.; General Treasurer, Mr. A. Walsh. (The retiring President, Prof. P. D. Hahn, M.A., Ph.D., is a member of Council, *ex-officio*.)

The following were elected as Members of Council for 1911-1912:—

I. Transvaal.—*Witwatersrand*: Mr. E. A. E. Collins, Mr. F. Flowers, F.R.G.S., F.R.A.S., Mr. J. A. Foote, F.G.S., Mr. A. Heymann, M.Ph., M.Ch., M.A., Prof. J. Orr, B.Sc., A.M.I.C.E., Prof. G. H. Stanley, A.R.S.M., M.I.M.E., Prof. J. A. Wilkinson, M.A., F.C.S., Mr. H. E. Wood, M.Sc., F.R.Met.S. *Pretoria*: Mr. W. E. C. Clarke, M.A., Mr. A. L. Hall, B.A., Mr. G. W. Herdman, M.A., M.I.C.E.

II. Cape Province.—*Cape Peninsula*: Prof. J. C. Beattie, D.Sc., F.R.S.E., Prof. H. Bohle, M.I.E.E., M.V.D.E., Prof. R. F. A. Hoernlé, M.A., B.Sc., Mr. J. M. P. Muirhead, F.S.S., F.R.S.E., Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S., Mr. A. H. Reid, F.R.I.B.A., F.R.San.I. *Kingwilliamstown*: Dr. A. W. Roberts, F.R.A.S., F.R.S.E. *Grahamstown*: Prof. A. Ogg, M.A., B.Sc., Ph.D. *Kimberley*: Dr. A. H. Watkins, M.R.C.S., M.L.A. *Queenstown*: Mr. W. B. Brown, M.A.

Stellenbosch: Prof. B. de St. J. van der Riet, Ph.D., M.A. *East London*: Dr. G. Rattray, M.A., F.R.G.S.

III. Orange Free State.—*Bloemfontein*: Dr. W. Johnson, L.R.C.S., L.R.C.P., Mr. C. C. Robertson, M.F., Prof. W. A. D. Rudge, M.A.

IV. Natal.—*Maritzburg*: Prof. E. Warren, D.Sc. *Durban*: Dr. A. McKenzie, C.M., M.R.C.S.

V. Rhodesia.—*Bulawayo*: Mr. Franklin White. *Salisbury*: Mr. G. N. Blackshaw, B.Sc., F.C.S.

VI. Basutoland.—Rev. E. Jacottet.

It was decided that two additional members of Council for Witwatersrand should be elected at a later date. The Council was also authorised to fill the vacancies in the representation of the Potchefstroom and Port Elizabeth centres.

Grants for Research.—A telegram was received from Dr. A. W. Roberts expressing regret that illness prevented his submitting a report, which would, however, be forwarded later.

Annual Session in 1912.—The President announced that an invitation had been received from the Mayor of Port Elizabeth to hold the next Annual General Meeting in Port Elizabeth, and it was unanimously agreed to accept the invitation.

Votes of Thanks.—Prof. Hoernlé moved the following votes of thanks, which were carried by acclamation:—

> To the Honourable the Legislative Council of Rhodesia for the grant of £100; to His Worship the Deputy Mayor of Bulawayo; to the Department of Education and the Trustees of the Public Library for the use of their rooms; to the South African, Beira and Mashonaland and Rhodesia Railways Administrations for travelling facilities granted; to the Municipality of Bulawayo for illuminations and concert in the Park; to Mr. and Mrs. Percy S. Inskipp; to the respective Secretaries and Members of the Reception Committee, the Excursions and Entertainments Committee, the Hospitality Committee, the Press and Publications Committee, the Finance Committee, and the several Sectional Committees; to the Bulawayo Club for the privilege of honorary membership; to the Bulawayo Golf Club for the hospitality of the golf greens; to all who have so kindly given hospitality to visitors; to the Honorary Auditors; to the Press for publicity given to the Association's proceedings; to Mr. R. N. Hall for books provided, for conductorship to the Khami Ruins, and for invitations to the Bushman's Haunt; to Mr. Dowsett for conductorship at the World's View; to Mr. Moffat for privilege of visiting the Old Nic Mine; and to Mr. G. N. Bromehead, Local Secretary.

Mr. A. T. C. Molyneux moved a vote of thanks to the Retiring President; this was also carried by acclamation.

The meeting then closed.

REPORT OF THE COUNCIL FOR THE YEAR ENDED 30TH JUNE, 1911.

1. Your Council, in submitting the following report on the work of this Association for the twelve months, July 1st 1910, to June 30th, 1911, ventures to draw attention to the difficulty of preparing a report for submission within a week after the close of the year covered thereby, and asks for indulgence owing to the obvious impracticability of placing the present report before members at the commencement of the present session

2. THE LATE DR. BOLUS.—Your Council records with the deepest regret the decease of Dr. H. Bolus, F.L.S., to whom, at the Bloemfontein meeting of the Association two years ago, the second award of the South Africa Medal was made. To botanical science, and especially in connection with the South African flora, Dr. Bolus had rendered great and lifelong service.

3. MEMBERSHIP.—During the year now closed the membership of the Association has slightly increased. At the close of the previous year there were 693 members on the Association's books; since the 1st July, 1910, 69 new members have been admitted; on the other hand, 6 members have died, and 37 have either resigned or were removed from the roll of membership owing to other causes. The membership at the close of the year now under report was, therefore, 719, 31 of these being life members. The provincial distribution of these members was as follows:—

Transvaal	276
Cape Province	253
Orange Free State	53
Natal	36
Rhodesia	34
Basutoland	12
Mozambique	7
Swaziland	1
German South-West Africa	1
Resident Abroad	27
Residence Unknown	19
Total	719

4. REPORT OF THE BLOEMFONTEIN MEETING, 1909.—Publication of the Association's sixth Annual Volume has now been completed, and steps have been taken for binding the loose parts on behalf of any members who may be so desirous The volume as complete comprises in all 535 pages.

5. REPORT OF CAPE TOWN MEETING, 1910.—The printing of the records of the last Annual Session is not yet complete, having been considerably delayed by the Printers' Strike during the last few months. Eight monthly parts have thus far been issued, and it is hoped to complete the Seventh Annual Volume

by the issue of two more such parts. It will therefore be somewhat smaller in size than the Bloemfontein Report.

6. South Africa Medal Fund.—On the recommendation of the South Africa Medal Committee, consisting of Mr. S. S. Hough, M.A., F.R.S., Prof. S. Schönland, M.A., Ph.D., Mr. T. Reunert, Dr. G. S. Corstorphine, Dr. C. F. Juritz, Mr. W. Cullen, Dr. A. Theiler, C.M.G., Mr. E. N. Nevill, F.R.S., F.I.C., Prof. G. Potts, M.Sc., Ph.D., Prof. J. C. Beattie, D.Sc., F.R.S.E., Prof. L. Crawford, D.Sc., F.R.S.E., and Dr. J. R. Sutton, the fourth award of the South Africa Medal, together with a grant of £50, has been made to Dr. Louis Péringuey, F.E.S., F.Z.S.

The Medal Fund (exclusive of the above £50) now amounts to £1,408, of which £1,376 is invested in a Cape Treasury Bill and bears interest at the rate of four per cent. per annum.

The difficulty of obtaining votes from members of the Medal Committee when the time for the annual award draws near and those members are absent from the Union, impressed upon your Council the necessity of amending the rules regulating the award. The amendments referred to in the last Annual Report were unfortunately precluded from consideration at the Cape Town meeting last year. They will now again be submitted to you.

7. Constitution.—Other difficulties have also been experienced by Council in its desire to adhere in all points to the spirit, if not in the letter, of the Constitution, and the mandate which you placed upon the Council last year, to appoint a special committee for the purpose of considering amendments to the Constitution, has been given full effect to. The Committee's report has been duly weighed by your Council, and the amendments which will be submitted to you are the result of Council's most careful consideration.

8. Lectures.—The South African Lectures have been intermitted for the present year. Your Council trusts that they will be resumed in 1912.

9. Grants for Research.—Your Council has not yet been enabled to consider any applications for research. In this connection it may be mentioned that at the Cape Town Session of the Association a paper was submitted by Dr. A. W. Roberts on "The Period of the Variable Star S Arae." This paper has been printed in the Association's Journal. Dr. J. Stuart Thomson, to whom this Association had made a grant of £20, has laid before the Association a copy of a paper on "South African Alcyonaria," which was printed in the *Transactions of the Royal Society of Edinburgh* as the first of a series of papers which he intended submitting on the subject.

10. Standing Committees.—There still exist Standing Committees on Education, Anthropology and Forestry, but three years have elapsed since last a report was made by any of them. The subject of such committees has been specially dealt with

by your Council in the amendments to the Constitution above referred to as about to be submitted for your consideration.

11. GOOLD-ADAMS MEDALS.—The first instalment of these medals has been received, and awards have been made in accordance with the rules already adopted, to the following successful candidates at the last Matriculation and Senior Certificate Examinations of the Unviersity of the Cape of Good Hope.

Physics: C. V. von Abo, Boys' High School, Upper Paarl.

Chemistry: Morris Schwartz, Marist Brothers' School, Johannesburg.

Elementary Physical Science: George H. Duggan, Boys' High School, Kimberley.

Botany: Lilian E. Carver, Girls' High School, Pretoria.

Zoology: Donald H. Saayman, private study, Riversdale.

Mathematics: Pieter J. Louw, High School, Caledon.

12. ASSOCIATION'S OFFICE.—During the current year your Council was successful in acquiring more suitable and centrally situated offices for the Association, in the Cape of Good Hope Savings Bank Buildings, St. George's Street, Cape Town. It has now, for the first time, been possible to make adequate provision for the Association's Library, and in addition to individual books available for reference by members, regular files are now kept of eight-seven scientific periodicals, memoirs, and transactions of learned societies and associations, who are good enough to supply their own publications in exchange for those of this Association, and to whom collectively and individually your Council feels much indebted.

13. MEETING IN 1912.—Arrangements for the 1912 Meeting are not yet completed, and it is suggested that the incoming Council be authorised to deal with the matter as may seem desirable in the interests of the Association.

14. THE NEW COUNCIL.—On the assumption that your Council's recommendation to allow a quota of twenty members of the Association for each member of Council, will be accepted, it is suggested that the distribution of Members of Council for the ensuing year be as follows: —

Transvaal:	
Witwatersrand	10
Pretoria	3
Potchefstroom	1
Cape:	
Cape Peninsula	6
Stellenbosch	1
Kingwilliamstown	1
Grahamstown	1
Kimberley	1
Queenstown	1
Port Elizabeth	1
East London	1

The South Africa Medal.

Orange Free State:	
Bloemfontein	3
Natal:	
Pietermaritzburg	1
Durban	1
Rhodesia:	
Bulawayo	1
Salisbury	1
Basutoland	1

SOUTH AFRICA MEDAL AND FUND.

(Raised by Members of the British Association in commemoration of their visit to South Africa in 1905.)

After the conclusion of the Presidential Address in the Hall of the Grand Hotel, Bulawayo, on Monday, July 3, the President, Prof. P. D. Hahn, handed the South Africa Medal and grant of £50 to Dr. L. Péringuey, F.E.S., F.Z.S., Director of the South African Museum, Cape Town. In doing so the President said that it was usual for the Association, at its Annual Session, to present this medal, which was bestowed for achievement and promise in scientific research in South Africa, and was awarded to persons whose scientific work is likely to be usefully continued by them in the future. This year it had been decided to award the medal to Dr. Péringuey. Dr. Péringuey had for many years conducted entomological research in South Africa; in fact, his work in that department had been so important that he might well be called the father of South African entomology. It was, moreover, of such importance that the University of the Cape of Good Hope had bestowed upon him the honorary degree of Doctor of Science. He had pleasure in presenting Dr. Péringuey with the medal, together with the grant which accompanied it, in recognition of the valuable services which he had rendered to science in South Africa.

Dr. Péringuey expressed his thanks in suitable terms.

Previous Recipients.

1908. *Grahamstown.*—Arnold Theiler, C.M.G., M.D., Bacteriologist to the Transvaal Government, Pretoria.

1909. *Bloemfontein.*—Harry Bolus, D.Sc., F.L.S., of Sherwood, Kenilworth, Cape Division.

1910. *Cape Town.*—John Carruthers Beattie, D.Sc., F.R.S.E., Professor of Physics, South African College, Cape Town.

ASSOCIATION LIBRARY.

The following publications are regularly filed at the office of the Association, Cape of Good Hope Savings Bank Buildings, St. George's Street, Cape Town, and are available for perusal by members daily between the hours of 9.30 a.m. and 12.30 p.m.:—

General Science.

Memoirs of the Royal Society of South Australia.
Transactions of the Royal Society of South Australia.
Proceedings of the Royal Society of Edinburgh.
Proceedings of the Royal Society of Victoria.
Proceedings of the Royal Institution of Great Britain.
Proceedings of the Royal Philosophical Society of Glasgow.
Journal of the Royal Society of Arts.
Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften.
Servian Royal Academy of Sciences: Comptes rendus.
Servian Royal Academy of Sciences: Year Book.
Atti della Reale Accademia dei Lincei, Rome.
Kungl. Svenska Vetenskapsakademiens Handlingar.
Kungl. Svenska Vetenskapsakademiens Arsbok.
Verhandelingen der Koninklijke Akademie van Wetenschappen, Amsterdam.
Koninklijke Akademie van Wetenschappen, Amsterdam: Proceedings of the Section of Sciences.
Revista de la Real Academia de Ciencias de Madrid.
Report of the British Association for the Advancement of Science.
Report of the Australasian Association for the Advancement of Science.
Atti della Società Italiàna per il progresso delle Scienze.
Transactions of the Cambridge Philosophical Society.
Proceedings of the Cambridge Philosophical Society.
Memoirs and Proceedings of the Manchester Literary and Philosophical Society.
Proceedings of the American Philosophical Society.
University of Virginia: Philosophical Society Bulletins.
Annals of the New York Academy of Sciences.
Proceedings of the American Academy of Arts and Sciences.
Proceedings of the Californian Academy of Sciences.
Transactions of the Academy of Science of St. Louis.
Proceedings of the Academy of Natural Sciences of Philadelphia.
Archives Néerlandaises des sciences exactes et naturelles.
Annaes scientificos da Academia polytechnica do Porto.
Proceedings of the Rhodesia Scientific Association.
Memoires de la Société de physique et d'histoire naturelle de Genève.

Comptes rendus des séances de la Société de physique et d' histoire naturelle de Genève.
Sitzungsberichte der Gesellschaft naturforschender Freunde, Berlin.
Vierteljahrsschrift der naturforschenden Gesellschaft, Zurich.
Bulletin of the Imperial Institute.
Transactions and Proceedings of the New Zealand Institute.
Annual Report of the Smithsonian Institution.
Annual Report of the Smithsonian Institution (United States National Museum).
Annals of the Transvaal Museum.
Annals of the Natal Museum.
Field Museum of Natural History Publications.
University of Pennsylvania Museum Journal.
Bulletin of the Public Museum of Milwaukee.
Records of the Albany Museum.
Knowledge.

Chemistry, Metallurgy, and Geology.

Journal of the Chemical, Metallurgical, and Mining Society of South Africa.
Kungl. Svenska Vetenskapsakademien: Arkiv för Kemi, Mineralogi, och Geologi.
Transactions of the Geological Society of South Africa.
Records of the Geological Survey of New South Wales.
Memoirs of the Geological Survey of New South Wales.
Bulletins of the Geological Institution of Upsala.
Abstracts of Proceedings of the Geological Society, London.
Bulletins of the United States Geological Survey.
United States Geological Survey, Professional Papers.
United States Geological Survey, Annual Reports.

Meteorology.

Quarterly Journal of the Royal Meteorological Society.

Agriculture.

Annali della Regia Scuola superiore agricoltura di Portici.
International Institute of Agriculture, Rome: Bulletin of Agricultural statistics.
International Institute of Agriculture, Rome: Bulletin of the Bureau of Agricultural Intelligence and of Plant Diseases.

Biology and Physiology.

Bulletin de la Société Imperiale des naturalistes de Moscou.
Kungl. Svenska Vetenskapsakademien: Arkiv för Botanik.
Kongl. Svenska Vetenskapsakademien: Arkiv för Zoologi.
Journal of the Linnean Society.
Bulletin of the Wisconsin Natural History Society.
Transvaal Medical Journal.
University of California: Publications in Botany.

Smithsonian Institution (United States National Museum): Contributions from the United States National Herbarium.

Entomology.

Report of the South African Central Locust Bureau.
Zeitschrift für wissenschaftliche Insektenbiologie.

Astronomy, Mathematics and Physics.

Memoirs of the Royal Astronomical Society.
Monthly Notices of the Royal Astronomical Society.
Transvaal Observatory Circulars.
Observatoire Royal de Belgique; annuaire astronomique.
Journal of the British Astronomical Association.
Memoirs of the British Astronomical Association.
Kungl. Svenska Vetenskapsakademien: Arkiv för Matematik, Astronomi och Fysik.
Proceedings of the London Mathematical Society.
Die Tätigkeit der physikalisch-technischen Reichsanstalt, Charlottenburg.
Report of the National Physical Laboratory, Middlesex.
National Physical Laboratory: Collected Researches.
Proceedings of the Physical Society of London.

Political Economy and Social Science.

United Empire.
International Institute of Agriculture, Rome: Bulletin of the Bureau of Economic and Social Intelligence.

Geography, Oceanography and Hydrography.

Società Italiana per il progresso delle Scienze: Bollettino del Comitato talassografico.
The Geographical Journal.
Bulletin of the American Geographical Society.
United States Geological Survey: Water Supply Papers.

Engineering.

Proceedings of the American Institute of Electrical Engineers.
Journal of the South African Institute of Engineers.
Transactions of the South African Institute of Electrical Engineers

Technology.

Patents for Inventions: Abridgments of Specifications.

PRESIDENT'S ADDRESS.

ADDRESS

BY

PROFESSOR PAUL DANIEL HAHN, M.A., PH.D.,

PRESIDENT.

I must thank the Council of this Association for the honour of having been elected President of the Association for the current year. Having been engaged for over thirty-five years in teaching Science and in propagating and spreading scientific knowledge, I consider my present position a compliment to the profession to which I have the honour to belong. At the Annual Meeting of the South African Association for the Advancement of Science a review of the progress, advancement, and present condition of teaching of Science in our colleges is certainly a very appropriate subject for a presidential address; more so because I find that this important subject has not been dealt with by my predecessors in their presidential addresses. Last year Dr. Muir, Superintendent-General of Education in the Cape Province of the Union of South Africa, referred to " the State's duty to Science." Amongst other interesting statements Dr.

Muir gave us a sketch of the organisation of the teaching of Science from the lower schools to the University. He said:—

"The first great duty of the State towards Science is to provide an effective and comprehensive system of national education. In the lower stages of the system direct and formal instruction in Science need not bulk very largely. What is essential is that the pupil shall throughout his course be trained to observe, to think, and to reason. In the middle stages—the stages covered by secondary schools of all classes—the actual study of Science, and especially of scientific method, must form a larger and ever increasing part of the curriculum."

Without going into details under these heads Dr. Muir continued:—

"It is sufficient for our present purpose to insist in connection with both on the desirability (1) of fostering rather than repressing the natural curiosity of the young; (2) of constantly recurring to the study of things in supplement to that of words; (3) of training the hands in the use of appropriate tools other than the pen; (4) of gradually introducing research methods into class-room work. It is the neglect of this advice that has been a main cause in the retardation of Science. It has also helped to make school-life a byword for dulness, and in many cases made the after-life unintellectual and even trivial. When we come to the higher stages—the stage of the University, and more practical institutions co-ordinate therewith—the interest in our subject naturally increases, for there we look not only for instruction in Science and training in scientific method, but for a steady flow of fresh contributions to the stock of human knowledge. That this last is a legitimate expectation is now the received opinion throughout the whole civilised world."

At the outset let it be understood that what Dr. Muir sketched in the passages which I have quoted from his address is an ideal organisation of the teaching and study of Science for schools and University colleges, which I regret to say is not in existence in South Africa at the present time. We are now only striving and struggling towards the realisation of this ideal organisation, but I firmly hope that the time is not far when we shall have attained this object at least in connection with the University colleges, considering the progress which the teaching and studying of Science has made in our colleges during the last forty years.

The University of the Cape of Good Hope was called into existence by the University Incorporation Act passed by the Cape Legislature in 1873. The calendars of the University published during its first years give us accurate information as to the Science subjects which figured in the syllabuses and in the papers of the two examinations which in those days were the two principal examinations conducted by the University, *viz.*, the Matriculation Examination and the Bachelor of Arts Examination. The teaching of Science subjects in the colleges where the candidates preparing their examinations were studying was, of course, limited to what was prescribed in the University Calendar. I may here already remark that at that time the students for the Matriculation Examination were almost exclusively prepared at the colleges, whereas at the present time none of the colleges of the Union has Matriculation classes, the entrance to the colleges being now the Matriculation Examination or its equivalent, as is the case in the Universities of England.

In the syllabus for the Matriculation Examination (Calendar, 1876, page 50) it is stated:—

Candidates for Matriculation shall be examined in the following subjects:—

1. Languages, Literature and History.
    (1) The English Language and its History.
    (2) The History of England and Modern Descriptive Geography.
    (3) The Greek and Latin Languages.
    (4) Modern Languages—Dutch or French or German.

2. Mathematics.
    (1) Arithmetic.
    (2) Elementary Algebra.
    (3) Plane Geometry, the first Four Books of Euclid.

3. Physical Science, *viz.*, Physical Geography or Geology or Chemistry, as may from time to time be notified by the Council.

From this syllabus it appears that in those days the literary and mathematical subjects were predominant and compulsory, but it is satisfactory to note that at least one Science subject was amongst the compulsory subjects. A footnote informs us that for the year 1876 *The Elements of Inorganic Chemistry* were prescribed. In subsequent Calendars we find the footnote, "Chemistry or Geology, at the option of the candidate."

In 1896, however, the Science subject was relegated to the rank of an optional subject, the University Council being evidently of opinion that some knowledge of the *English Language* with one *Modern Language*, the *Latin Language, Arithmetic, Geometry* and *Algebra* is sufficient to start a young man in life, and this in our times, in which all and every progress which the civilised nations of the world make depends directly or indirectly upon the progress of pure and applied sciences.

This deplorable condition in which the Science subjects had been placed lasted fourteen years, and only recently, in 1909, the Science subjects were reinstated in their proper place in the Matriculation Examination, and at present the regulations for this examination require a candidate to show a competent knowledge of either Chemistry or Physics or Botany or Zoology. It is true that the standards in these subjects are not very high, but considering that the candidates for the Matriculation are at present prepared at the High Schools, which have only a very scanty outfit of apparatus and material for teaching these subjects experimentally, we cannot make such great demands at the present time. If we compare the examination papers in the Science subject, Chemistry, of to-day and of the early years of the University, it is evident that no progress has been made, but that the standard in the Science subject in the Matriculation Examination is now lower than in the first period of the University's existence. Whilst the Matriculation candidate had formerly the option of Chemistry or Geology, he has now the option of Chemistry, Physics, Botany or Zoology.

The B.A. Degree in the early days of the University was a so-called *mixed* degree. The regulations stated:—

"Candidates shall be examined in the following subjects:—

1. Languages, Literature and History.
   (1) The Constitutional History of England.
   (2) The English Language and Literature.
   (3) Modern Languages—Dutch or German or French.
   (4) The Greek and Latin Languages.
   (5) Ancient History.
   (6) Outlines of Logic.
2. Mathematics.
   (1) Arithmetic.
   (2) Algebra.
   (3) Plane Geometry.
   (4) Plane Trigonometry.
   (5) Plane Co-ordinate Geometry.
   (6) Elementary Mechanics.
3. Physical Science. Any one of the following subjects to be selected by the Candidate:—
   (1) Chemistry—Inorganic Chemistry.
   (2) Light and Heat.
   (3) Electricity.

We are surprised to find so large a number of subjects for one examination, and do not expect that in all these subjects the standard was very high. For example, in Chemistry it was only Inorganic Chemistry, of about the standard of Chemistry in the present Intermediate Examination, less the practical laboratory training which the candidates for the Intermediate Examination are nowadays expected to have gone through.

The former B.A. candidate was not expected to have had any practical laboratory teaching; at the colleges he had in the Science subjects merely blackboard instruction, and at home book study.

A radical change was made in connection with the B.A. Examination in 1883, when a new examination, the present Intermediate Examination, was interposed between the Matriculation and the B.A. Examination, and the B.A. Examination itself divided into two branches:—

1. Literature and Philosophy.
2. Mathematics and Natural Science.

The standard of all the various branches of Natural Science was considerably varied. They comprised at first: —

1. *Chemistry*: Inorganic Chemistry, Organic Chemistry, Agricultural Chemistry and Chemical Analysis.

2. *Physics*: Light, Heat, Sound, Electricity and Magnetism.

3. *Geology*: Petrography, Mineralogy and Crystallography.

A candidate for the B.A. Degree had to study one of these three subjects, and, in addition, the various subjects mentioned under the heading of Mathematics.

The syllabus for the B.A. Science Examinations subsequently underwent further changes, all in the direction of extending the study of the Science subjects and of requiring every student to have undergone a thorough practical training in the laboratories, the latter forming a prominent part in the final examinations. It is impossible to give you to-day a full account of the syllabus of the Science subjects for the B.A. Examination as they are at present. They occupy twenty-five pages of close print in this year's Calendar. It may suffice to say that the standards for the Pass and Honours Examinations in all the Science subjects for the B.A. in the University of the Cape of Good Hope are not below the standard of these subjects in the corresponding University examinations in England, the States, and the Continent. The colleges in South Africa, where our students are devoting themselves to the study of one or more branches of Science, are doing—or are attempting to do—real *Higher Education* in Science. The requirements in these subjects for our Honours B.A. Degree are fully equal to those for the Prussian examination *pro facultate docendi*, which qualifies for the teaching in the German Gymnasium. The candidates enter this examination after a three or four years' course of study in a German University.

It is frankly admitted that the University of the Cape of Good Hope, which is only an examining and degree-conferring body, has done much to encourage and promote the study of the various branches of Science amongst the rising generation in South Africa, and has thus considerably advanced the cause of Science in South Africa. The last sixteen years have witnessed in South Africa the establishment of institutions, which prepare and train our young men for the practical and technical professions. I refer to the School of Mines, the Engineering Department of the South African College, and the Agricultural Schools in different parts of South Africa.

In 1894 the Council and Senate of the South African College, Cape Town, took the initial steps for the establishment of a South African School of Mines. With the co-operation of De Beers at Kimberley, and of the Chamber of Mines at Johannesburg, the Council of the South African College started the School of Mines in 1896. The preliminary scientific training was given at the colleges in the Cape Colony, the first part of the practical training at Kimberley, and the second part of the practical training at Johannesburg. The University had made the necessary arrangements for conducting the examinations, and all went well until the War broke out in 1899. It was only natural that when peace was restored, the School of Mines, under the new order of things, should gravitate to the centre of the mining industry, to Johannesburg. After some changes and further developments in Johannesburg it exists now as the *South African School of Mines and Technology*, with a large staff of Professors, Lecturers, Demonstrators and Instructors. Under agreement wth the Council and Senate of this institution, the South African College, and the other colleges which possess the necessary equipment and facilities, continue to prepare students in the Science subjects of the first and second years' mining course, after which the students proceed to the Johannesburg School of Mines and Technology. A very large number of young South Africans have gone through this School, and it is most gratifying that the young men who have received their theoretical and practical training in this School have been subsequently very successful in obtaining good positions, and in holding their own, professionally and otherwise, against all-comers. The mining profession evidently appeals to the South African youth, because the number of students joining this course is not decreasing.

In consequence of the success which accompanied the development of the School of Mines, the Council of the South African College decided to make further provision for scientific and technical training, by establishing an Engineering Department in connection with the South African College. After the erection of suitable buildings, and the appointment of Professors and Demonstrators, this Department commenced operations in 1904. According to its present organisation, it provides, in a four years' course—including one preliminary year—a complete training for the profession of Civil and Electric Engineering. A special feature of the training of students in this Engineering Department is the regular excursions and greater tours in the vicinity of Cape Town, and through the more distant parts of the country, under the guidance of one or more professors, for the purpose of inspecting the larger irrigation works and technical and industrial establishments. This engineering course is very well laid out and carried out, a fact which is confirmed by the recognition of the Diploma of the Engineering Department of the South African College by the Institute of Civil Engineers in England. The Department is well attended. After having successfully passed the final examination, many have received the diploma and are now engaged in irrigation works and railway construction throughout the Union, and even to the north of the Zambesi. They are the recruits for the officers in the Railway and Public Works Departments of the Provinces of the Union and of Rhodesia.

Another important development in the direction of teaching Science is the establishment of a Medical School for South Africa. It is difficult to understand why South Africa had not its Medical School long ago, considering that Australia and New Zealand have their own Medical School, and that the Dominion of Canada possesses many Medical Schools. For some years past, students, who intended studying medicine, took the first year's subjects—Botany, Zoology, Physics and Chemistry—at the South African College, and some of the other colleges which could provide the teaching in all these subjects. The students then proceeded to England, and were at once admitted to the first professional examination. This examination, at the end of the first year's medical course, is now held by the University of the Cape of Good Hope, and is recognised by the Medical Faculties of the Scottish Universities. The Council of the South African College has now taken a further step in connection with the establishment of a Medical School for South Africa by appointing Professors of Anatomy and Physiology, and by erecting suitable buildings for the Anatomical and Physiological Institute. When this is complete the South African Medical student will be able to take the first two years of the medical course in South Africa, and then proceed to Europe for the study of the clinical subjects. But I have no doubt that it will not be many years before we shall have in South Africa a fully equipped and efficient Medical School, which will bear comparison with any of the Medical Schools in the other Dominions of the Empire.

I cannot conclude this part of my address without referring to the Agricultural Schools which have, of late, been called into existence, and in which those sciences are taught on which the intelligent study and practice of agriculture depend.

The first attempt to establish an Agricultural School was made in Stellenbosch, and the first impetus was given in connection with the festivities at the bicentenary birthday of that beautiful village. It was at first intended to have this Agricultural School in connection with the Stellenbosch College. After some changes it has now developed into an independent Agricultural School, and is located on the farm Elsenburg, near Stellenbosch. Other agricultural schools have been founded at Middelburg in the Cape Province, and at Potchefstroom in the Transvaal, and it is to be hoped that in every province of the Union—and in Rhodesia—a number of Agricultural Schools will be founded, according to the words of our Minister of Education, Mr. Malan:—

"We must have more Agriculture in Education and more Education in Agriculture."

The principal industry in South Africa will always be Agriculture in all its branches, and we cannot bestow a greater benefit on the coming generation than by spreading scientific principles and methods, combined with intelligent practical application, amongst the farming community. This should be done not only at the Agricultural Schools, but at all first and second-class schools, by introducing into the curriculum of the Government Schools Elementary Agricultural Science. It is not intended to transform the boys at their schools into Analysts, Botanists or Zoologists, but they should receive so much intelligent instruction in the Elementary Agricultural Sciences as to enable them to profitably read and understand, and turn to use, the valuable information which appears in our agricultural journals in the Union as well as in Rhodesia. The value of the teaching of Science to the State and to the general social conditions of the people is perhaps best illustrated in Germany. According to Professor Wilhelm Ostwald of Leipzig, who is a great authority on the subject, the spreading of the principles of Agricultural Science in Germany has had the effect that that country can now produce foodstuffs for three times the number of people it had before elementary Agricultural Science had become part and parcel of the education of the people. It is true that at present large areas of arable soil in South Africa are not yet cultivated, but it should be remembered that profitable agricultural farming does not depend upon getting small returns from large areas, put under cultivation with much labour, but upon obtaining the maximum yield from a limited area by skilful cultivation.

I think that I have satisfactorily proved that the teaching of Science has been considerably advanced during the last forty years. There was no professorship or lectureship for any branch of Science in existence, in any of the schools or colleges of South Africa, forty years ago, whilst at the present time we have over sixty professors and lecturers appointed to teach certain branches of Science in our Colleges and Technical and Agricultural Schools.

It has been frequently asked: Are the colleges and technical schools in a position to carry out in a satisfactory manner the programme which they have put before themselves? Have their institutions a sufficient staff and a proper equipment of apparatus, materials, and practical means of instruction for teaching all the branches of Science, not merely by blackboard instruction, but practically and experimentally, which is admittedly the only efficient means of teaching a scientific subject?

Before I answer these questions I beg to draw your attention for a moment to a few figures, which I have taken from the annual reports issued by the Superintendent-General of Education of the Colony from 1894 to 1909. I must limit myself to Cape Colony, because I had no access to the reports issued in the other provinces:—

THE VOTE FOR HIGHER EDUCATION IN THE CAPE COLONY IN THE YEARS 1894 TO 1909.

	Total Vote for Education.	Vote for Higher Education.*	Percentage of Total Votes.
1894	£176,189	£8,964	5.03 per cent.
1895	181,370	9,093	5.01 ,,
1896	197,608	10,600	5.3 ,,
1897	204,947	10,492	5.1 ,,
1898	235,022	11,608	4.9 ,,
1899	270,758	15,599	5.7 ,,
1900	272,206	13,089	4.8 ,,
1901	278,049	16,390	5.8 ,,
1902	287,855	20,539	7.1 ,,
1903	314,956	19,229	6.1 ,,
1904	378,680	20,913	5.5 ,,
1905	447,796	24,765	5.5 ,,
1906	482,671	27,537	5.7 ,,
1907	537,836	23,455	4.3 ,,
1908	578,528	22,924	3.9 ,,
1909	521,687	25,535	4.8 ,,

These figures give the total expenditure for education, and the amount apportioned to Higher Education. Considering that about one-half of the vote for Higher Education falls to the Chairs and maintenance of Science subjects, and about one-half to the Chairs and maintenance of the Literary subjects, we arrive at an approximate estimate of how the State has discharged its duty towards Science, or rather to the advancement of Science in the colleges. It appears from these statistics that the vote for Higher Education in the years 1899 to 1906 was between 5 and 6 per cent. of the total vote for Education; in two years (1902 and 1903) it was a little above 6 per cent., and in two other years (1896 and 1898) it was a little under 5 per cent. During the last three years, 1907, 1908, 1909, the vote for Higher Education in the Cape Colony was only 4.3 per cent., 3.9 per cent., and 4.8 per cent. respectively, of which about one-half is apportioned to the Chairs and maintenance of the Science subjects, that is 2.15 per cent., 1.95 per cent., and 2.4 per cent.

I think these figures help us to understand the fact, that whatever has been done for the advancement of Science and teaching of Science in the colleges has been done on the initiative of the governing bodies of these colleges, and not on the initiative of the Government, except the establishment of the Agricultural School at Middelburg, which has been called into existence through the efforts of Mr. Malan, the present Minister of Education of the Union. These governing bodies of the colleges deserve the thanks of the people of South Africa for

* This includes the vote for the University.

what, they have done to advance the cause of Science in the colleges of the country.

I can now proceed to answer the question as regards the suitable equipment of the colleges for the efficient teaching of the Science subjects. To the best of my knowledge, there is not one college at the present time in the Union of South Africa which is supplied with the necessary amount of scientific apparatus, materials and practical means of instruction for the efficient experimental and practical teaching of all their students in all those subjects which are contained in the syllabuses of the Intermediate and B.A. Examinations. In this respect—that is to say, in the supply of the necessary apparatus, materials, and practical means of instruction—all our colleges are at present deficient and in a starving condition. Mr. Malan, our Union Minister of Education, is fully aware of this condition, but unless he has the co-operation of his colleagues in the Ministry and the support of Parliament, he is not able to materially assist the struggling colleges in advancing the cause of Science.

Notwithstanding the indifferent attitude of the Government of the Cape Colony during the last fourteen years, which manifested itself in the scanty and inadequate provision made for the teaching of Science in the colleges, it must be admitted, that some progress has been made, and that the country has derived some benefit from the increased facilities which have been provided by the governing bodies of the colleges for teaching and studying Science. Whilst formerly most of our young men studied Law, or Medicine, or joined the Church, at present a considerable proportion of the matriculated students proceed to the technical walks of life, taking up some branch of engineering, or they devote themselves entirely to the study of some branch of Science, such as Geology, Biology, Metallurgy, Chemical Technology, and others. We must look to these men particularly for carrying on research in their respective sciences. Owing to the fact that at the present time a large proportion of students follow the technical or purely scientific courses, the three professions, which were formerly the only choice for the ambitious South African student, have been considerably relieved, and in this respect the growth and development of the sciences at our colleges have had a most beneficial effect on the social condition of the people. What has been done up to the present is merely the beginning of a new development in our system of Higher Education. Much more remains to be done. The South African youth should receive in South Africa such scientific and technical training as to enable him to take his share in the development and in the scientific exploration of his native land, this large and beautiful country, South Africa.

But besides this growth of the Science Departments in our colleges, there are many signs, hopeful indications, of the steady progress and advancement of Science in South Africa. Is not the fact that we meet here to-day in Bulawayo, the geographical centre of South Africa, the most tangible proof for the advancement of Science in South Africa? Forty years ago this country was under the sway of a barbarian ruler, and now, this year, your town is the place of meeting of the South African Association for the Advancement of Science. You have schools, a museum, an observatory of no mean order, your Rhodesia Scientific Association, chemical laboratories—in short, everything that indicates that Science has found a home in the centre of this southern part of the Dark Continent. I have always read with the greatest interest the records of the Rhodesia Scientific Association, and of the *Rhodesian Agricultural Journal* published by your able Director of Agriculture, Dr. Eric Nobbs. The value of the scientific work done by your Agricultural Department cannot be overrated, and should receive every encouragement and support at the hands of the Government. Also in Rhodesia, notwithstanding its mineral wealth, agriculture in all its branches, which can be carried on under the climatic conditions of the country, will ever be the principal industry of this part of South Africa. The Agricultural Department of Rhodesia, as well as the Agricultural Departments in the several Provinces of the Union, should be in a position to advise the new settlers as to the most suitable crops to grow and the proper mode of cultivating these crops. In order to do this the Agricultural Departments in all the countries of South Africa should have under their control a large number of agricultural experimental stations, at which systematically arranged experiments should be carried out, the results of which would immensely help the new settler and spare him much disappointment and loss of money and time in his endeavours to obtain a footing and living in the new country. My colleague, Dr. Pearson, Professor of Botany in the South African College, delivered an extremely able address at last year's meeting of the Association in Cape Town on the subject of establishing National Botanic Gardens in the various climatically different parts of South Africa, in which such work is carried on as in an Acclimatization Garden. I much regret that up to the present, so far as I know, no action has been taken to carry out this suggestion. The colonies of Germany are but small as compared with those of the British Empire, but the amount of energy and money which is devoted by the Colonial Department in Berlin to the experimental agricultural work done in Togo, the Cameroons, East Africa and Samoa, with a view to testing the suitability of these countries—soil and climate—as to the production of crops such as Cotton, Hemp, Coffee, Tea, Tobacco and other tropical and subtropical plants is vastly greater than what we do in our newly acquired tropical and subtropical countries. I beg to refer you on this occasion to Dr. Pearson's address on National Botanic Gardens, to which he has added a paper on "A State Botanic Garden," which appeared in the periodical *The State* of May this year.

He very forcibly proved that the case for the establishment of a State Department of Botanical Research with the Botanic Garden as a fundamental part of its organization rests upon an economic basis. Now this should appeal to any Government which has the betterment of the economic conditions of the people and of the country at heart. We have the men in South Africa who can advise the Government in the organization of the agricultural and experimental stations and the National Botanic Gardens. There exists, therefore, no cause for delaying any longer this work, without which our Agricultural Departments are not of so much use for promoting and consolidating agricultural enterprise in South Africa as they would be if they could point out to the new settler their own experience obtained in the experimental agricultural stations.

On this occasion it is impossible to give a review of the progress of the various branches of Science during the last years; this must be left to those who have prepared papers in the several sections of this year's meeting. There is, however, one subject which has more than any other in recent years engaged the attention of men of Science, as well as of those who are not in the inner circle. It is the study of radium and of radioactive substances. Ever since the days of Lavoisier and of his contemporary workers in the field of Inorganic Chemistry, nothing has done more to widen and consolidate our knowledge of Inorganic Chemistry than the study of Mineral Chemistry. The great Swedish chemist, Jacob Berzelius, who advanced our knowledge of this subject more than the labours of others in the same field of research, gave a definition of a mineral which we may to-day accept without reserve. Berzelius stated that a mineral was simply a chemical compound occurring in nature. In devoting the greater part of his life to the investigation of the composition and constitution of these "chemical compounds occurring in nature." Berzelius had discovered a large number of elements new to Science. Others who followed the example of Berzelius have also enriched our knowledge in this field of research, and the study of the chemical and physical properties of the elements and of the mutual relations existing between the elements and their compounds of similar constitution has supplied that broad basis on which modern Inorganic Chemistry is founded. During the second half of last century the study of Organic Chemistry, and more particularly of the synthetical preparation of Organic Substances, was considerably advanced, in some centres of Germany to such an extent that the study of Inorganic Chemistry undoubtedly suffered. Only recently more attention has been given to the study of Inorganic Chemistry, and in many continental Universities and Technical High Schools separate chairs of Inorganic Chemistry and of Organic Chemistry are established with separate laboratories.

Towards the end of last century the study of Inorganic Chemistry and of Mineral Chemistry received a new impetus through the discovery of radium by Madame Curie in Paris, and of the radio-activity of thorium—a rare metal—and of thorium compounds by Professor Schmidt of Erlangen. Since the discovery of radium we have from time to time read of new discoveries in connection with radium and the constitution of matter, of the atoms composing matter, of the transformation of matter, of the wonderful physiological action of radium and radium emanation. The latter subject is of great interest to the general public. No doubt our medical men will have read with the keenest interest in the *British Medical Journal* the articles of Professor His of Berlin on the cures effected by the application of radium emanation in cases of gout and rheumatism, and of Dr. William Armstrong on Radium Water Therapy. This subject, the study of Radium Water Therapy, is still in its infancy, but will no doubt be followed up assiduously, and the results hitherto obtained are surprising and marvellous.

I shall not detain you longer with the subject of Radium; suffice it to say that I have found the springs at Montagu and Aliwal North distinctly radio-active, due to the presence of emanation, and that this emanation is radium emanation and not thorium emanation. The radium is associated in minerals principally with uranium. I have been searching now for four years for radium in South African minerals, but up to the present with only negative results. But since pitchblende, the principal source of radium, is found so far north as German East Africa, and since some of our mineral waters contain radium emanation, I cannot help thinking that radium-containing minerals do occur also in South Africa, and will eventually be found. At all events, I intend continuing the search for radium in South Africa.

In connection with the study of the radio-active minerals and elements a very important discovery was recently made by Professor Dr. Otto Hahn, of Berlin, of two radio-active substances, mesothorium and radiothorium. These two substances are formed from thorium in a similar manner to that in which radium is derived from uranium. Thorium oxide is largely employed for making the mantles of incandescent lamps, and is almost exclusively prepared from the monazite sands occurring on the coast of Brazil. The bye-products in the manufacture of thorium oxide mostly contain mesothorium and radiothorium, and were used by Professor Otto Hahn for the preparation of these two new elements, which emit the same rays as radium and act in the same manner. The life of these two elements is, however, not of the same duration as the life of radium, since they break up after ten to twenty years into non-radio-active substances, the nature of which is, however, at present little known. Mesothorium and radiothorium can, however, be obtained in larger quantities than radium, and are much cheaper. It may be of interest to learn that quite a number of radio-active minerals occur in South Africa, viz.:—Monazite from Embabaan in Swaziland, fergusonite and æschynite from the same locality, monazite from Houtenbek in the Transvaal, and orthite from Little Namaqualand. The radio-activity of all these minerals is, however, not due to the presence of radium, but to the presence of thorium, mesothorium and radiothorium, which could be prepared from these minerals.

Here in Rhodesia many minerals occur, and are even worked, which, according to the paragenisis of minerals, are associated with the thorium and uranium containing minerals. There is at present a considerable amount of chrome iron ore, of wolframite and scheelite, exported from Rhodesia, minerals which are met with in Europe and in the Ural Mountains in the same formation as the uranium and thorium minerals.

I shall not be surprised if Rhodesia will also be before long a producer of radio-active minerals.

Whatever the constitution and scope of work of the New Teaching University of South Africa will be, I trust that ample provision will be made for research in mineral chemistry, which has hitherto received only little attention in South Africa. I feel confident that research in mineral chemistry in South Africa will reveal and bring to light facts of great scientific interest and of practical and economic value.

There is something fascinating in research of this kind, by which new facts and new truths are brought to light. And those who have ever discovered a new truth by striving after truth will have undoubtedly had the reward which is expressed in the words of Frederick the Great:—

"Das lebhafteste Vergnügen, das ein vernünftiger Mensch in der Welt haben kann, ist, neue Wahrheiten zu entdecken; das nächste nach diesem ist, alte Vorutheile los zu werden."

(The greatest and noblest pleasure which men can have in this world is to discover new truths; and the next following this is to shake off old prejudices.)

SECTION A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE, AND GEOGRAPHY.

PRESIDENT OF THE SECTION.—REV. E. GOETZ, S.J., M.A., F.R.A.S.

WEDNESDAY, JULY 5.

The President delivered the following address:—

WEATHER FORECASTING.

I should have liked to give you a presidential address on the Meteorology of Rhodesia. But you have given us such short notice of your desire to hold your ninth Annual Meeting in Bulawayo that I have not been able to get through the amount of material work such a paper presupposes. I have, therefore, chosen a subject of more general interest, that of Weather Forecasting. This subject has, besides, a certain actuality. The Transvaal Meteorological Department has had a forecasting service for some years, and its success shows that this service should now be extended to the rest of South Africa.

It may be said that it was only during the second half of last century that the art of forecasting the weather, an art apparently as old as the world, was put on a scientific basis, when the close connection between the distribution of pressure over large areas and the weather in general was established as an undoubted fact. This connection had been suspected long before, and as far back as 1780 Lavoisier tried to establish a kind of meteorological service, based chiefly on the simultaneous observation of pressure at places as far apart as possible. This idea was taken up about the same time in a more systematic way by the Mannheim Meteorological Society, the oldest of all such societies, and a vast amount of data was collected by its members and others all over the west and centre of Europe. These attempts were not, however, successful owing partly to the disturbed state of the political world at the end of the eighteenth and the beginning of the nineteenth centuries, but chiefly, no doubt, to the lack of the rapid system of communication which the invention of the telegraph was to give us half a century later. From the twelve folio volumes of the Mannheim Society's Proceedings, W. H. Brandes, in 1820, extracted the data for a discussion of the weather day by day over Western Europe for the year 1783. This work of Brandes may be considered as the dawn of modern meteorology. He constructed weather maps for successive days, maps which he did not publish, but which may be reconstructed from the data he gives for them, and their discussion led him to the following conclusions: The wind direction is determined by the distribution of the pressure, the movement of the air being towards the centres of areas of low pressure. The weather in general is connected with the variations of pressure. The areas of low pressure have a general movement from West to East over Europe. These conclusions, which we now accept as exact, were not accepted in Brandes' time, for he was ahead of his generation. His thesis could not be reconciled with the theories then prevalent among meteorologists. The same ideas were revived later, owing especially to the study of tropical cyclones by Piddington in India and Redfield in America, and to the works of the great American investigators Espy and Loomis, on the disturbances of the Temperate Zones.

It is to Le Verrier chiefly that Meteorology owes the impulse that determined its start and progress on new lines, and brought it definitely into the realm of exact sciences. In November, 1854, during the Crimean War, a disastrous storm burst upon the Allied fleets in the Black Sea, and caused the loss of one of the French men-of-war. Le Verrier was commissioned by his Government to investigate this storm and to report on it. In his report he showed clearly that an atmospheric disturbance had crossed Europe from north-west to south-east in about four days, and that an organised meteorological service could have detected this before it reached the fleets, and given them timely warning. In conclusion, he strongly advocated the constitution of a regular daily service of meteorological information, telegraphed to Paris from a certain number of stations distributed throughout Europe. Both the Government and the public in general fell in with his plan, and in the course of a year Le Verrier had organised the first international service of more or less simultaneous observations. Synoptic charts were drawn up regularly and a bulletin published. His initiative was followed by Fitzroy in England and Buys Ballot in Holland. The aim of Le Verrier was to organise a weather prediction service. But the material difficulties which he encountered, and especially the slackness of the Government in supplying the necessary funds when once the first enthusiasm had cooled down, robbed him of the honour of being first in the field. His rivals abroad, Fitzroy and Buys Ballot, had been before him. It is interesting to note that Le Verrier met with rather strong opposition in the scientific circles of the day. The great physicists Biot and Regnault, for instance, energetically opposed his plans. One can easily understand Regnault's attitude. With his refined methods of investigation, which have been the bugbear of our schooldays, Regnault was perhaps ill-prepared to see what results could be obtained from the cruder methods of meteorological investigation. Le Verrier, however, by the force of his genius, the tenacity of his will, and, we may add, perhaps also by the dread which his none too sweet temper inspired, bore down all resistance, and the results he obtained very soon showed the accuracy of his views.

As soon as the synoptic daily charts covered a sufficiently large area, and extended over even a comparatively short period of time, it became evident that there existed certain definite systems of atmospheric pressure, for the isobars or lines drawn through points of equal pressure affected day after day certain well-defined forms. An isobaric chart presents most of the features of a hypsometric map. It has, for instance, closed areas of more or less circular isobars with figures decreasing to a central minimum, others with figures increasing to a central maximum; V-shaped isobars with figures decreasing or increasing inwards, like the contour lines of valleys or mountain spurs; and so on. Each system of isobars, as it recurred, was found to be accompanied by the same general features in the weather Storms, for instance, invariably corresponded to a system of closed isobars with low central pressure, whilst continued fine weather corresponded to a system of closed isobars with central high pressure. These areas of closed isobars were, therefore, the earliest objects of methodical research.

The first fact to be well established was that the winds had a clearly defined system of circulation round the closed areas of pressure, clockwise round the areas of high pressure, and counterclockwise round those of low pressure. The same was found to hold for the southern hemisphere with the direction of rotation reversed. This circulation was briefly formulated by Buys Ballot in the following words:—

"Put your back to the wind, and you have the low pressures on your left in the northern hemisphere, and on your right in the southern."

It is easy to see what importance this law, which we may consider as the fundamental law in modern meteorology, had in his day when steam navigation was still in its infancy. It soon became also evident that the force of the wind—as well as its direction—was in close connection with the shape of the isobars. Strong winds almost invariably corresponded to a system of closed isobars, and patient investigation gave a rough determination of the relations between the strength of the wind and the closeness of the isobars. These discoveries were the first to be applied to the prediction of storms, for about 1860 we already find storm warnings sent to many ports in Europe.

The general connection of the weather with the pressure systems was, of course, detected at the same time, but progress in this direction has been considerably slower. There are many influences to be taken into account in following the variations of the weather with those of the pressure from day to day. An army of investigators has been at work for the last fifty years in unravelling this tangle. On the whole, it may be said that the weather in general depends on the presence of high and low areas, and its changes on their movement. A low area, indifferently called cyclone or depression, is characterised by cloudy and rainy weather. In front of the depression there are no permanent rains; as soon as the depression approaches a certain area, high feathery clouds, cirrus clouds, appear, soon to be followed by lower stratified clouds. The sky gets dirtier, the air muggy, as the centre, or rather the central trough, of the depression gets nearer. Rain sets in, persistent rain covering large tracts of land. The cloud and rain areas are roughly concentric with the pressure area. After the passage of the central trough of low pressure, the rains are more in the shape of showers, and the clouds are broken up by patches of blue. When the depression has passed fine weather sets in again as a rule. Thunderstorms, according to the season of the year, are associated with the passage of these depressions, and are generally located in a special quarter—the south-western quarter of Europe.

High-pressure areas or anticyclones bring cloudless and dry weather with light winds. They are of a more permanent character than the preceding ones, hanging longer over the same regions. The cyclones as a rule bring warm, the anticyclones cool, weather. The seasons, however, have here to be taken into account. An anticyclone in winter will bring periods of intense cold, nights especially with very low temperatures owing to intense nocturnal radiation under a clear sky. In summer, on the contrary, owing to their permanency over the land and the protracted absence of clouds, anticyclones may produce intense heat, but in this case it is a dry heat, very different from the oppressive heat of the summer cyclones. A cyclone gives mild or oppressive heat according to the season. There is a distinct difference in the temperature of the different parts of a cyclone. The front is warmer than the rear. In winter, of course, the north-western quarter in America and the eastern in Europe may be intensely cold, as they draw into the cyclone the air from land areas which may at the time be subject to very low temperatures

I cannot here describe the other pressure systems. There is only one to which I will allude, as it has apparently a certain importance in South Africa. It is the one represented by a V-shaped system of isobars, with pressures decreasing inwards. This system sweeps over the land broadways from west to east. In South Africa its apex is directed northwards, and reaches to the tropics. I have reason to believe that it occasionally reaches right into Rhodesia. It is characterised by winds of a northerly direction in front, and of a southerly direction in the rear. When the middle line of the trough passes over a region there is a sudden calm, lasting for a comparatively short time. The wind, which had been northerly before, springs up suddenly from a southerly direction, bringing with it duststorms, and in summer terrific thunderstorms, with heavy rains.

This may be sufficient to give a summary idea of the basis of modern weather forecasting.

If we now pass to the practice of weather forecasting, we have to deal with a far less satisfactory branch of meteorology.

The problem which the forecaster has to solve every day is the following: Given the isobaric chart of to-day, to construct the isobaric chart of to-morrow. The degree of certitude of the forecasts is, if not equal, at least largely proportional, to the degree of certitude with which this problem can be solved. It must be confessed that we have no solution of this problem. It is sometimes said that meteorology still awaits its Newton. I am afraid that meteorologists have no such ambition. To solve the problem of the weather by analytical methods seems beyond our limitations. The problem is chiefly one of hydrodynamics. A great deal has been done by mathematical physicists in hydrodynamics; but when it comes to applying their theories to the atmospheric circulation, the problem becomes a singularly complex one. The physicist, in his theoretical investigation, deals with masses subjected to determined conditions of temperature, pressure, humidity, friction, viscosity, etc. If he introduces variations in the conditions, he fixes the law of these variations. He can then deduce the laws of the motion of fluids, laws which he can even verify by laboratory experiments. But when he turns to the atmosphere, he finds that he has to deal with masses out of all proportion with those he can control in his laboratory experiments. He has to deal with masses that are subjected to no very definite conditions of pressure, humidity, temperature or friction, in which, moreover, these conditions change according to laws about which he knows little or nothing. He has, therefore, to solve what we may consider the most difficult problem of mathematical physics. He can only build up the edifice of his theory by sections, and when he has built up his sections, to go on with our metaphor, he finds that to fit them together is worse than any Chinese puzzle, for the sections are not to be juxtaposed since they compenetrate one another; to use the words of one of the leading meteorologists of the day:

> "The atmosphere has no simple circulation, cyclonic or anticyclonic, but is a mass of interlacings of currents."

Although the analytical method has been used with brilliant success during the last fifty years or so, it cannot be said that it has been pushed far enough to give us hopes that we will eventually find the solution of the weather problem in this way.

We have, therefore, to turn up the inductive method, based principally in this case on statistics and averages, a method which may perhaps help us to find the laws without, however, telling us anything about their nature or about the way in which they are applied, as the preceding method would do. Statistical methods are subject to a great deal of distrust. "You can prove anything with statistics," is sometimes said. But this is not true if statistical methods are properly applied. Statistics are to be applied within limits imposed by the nature of the subject and the nature of the observations, or you may come to absurd conclusions. It would be easy, by statistics and averages, to prove that the mean path of cyclones is over the equatorial regions where, in fact, they do not occur. Statistics are to be applied to reliable documents, which, needless to say, is very often neglected. They are to be applied to a large number of observations if the results are to represent a physical fact, and not merely a meaningless arithmetical result. But, above everything, one must have, in applying the statistical method, an open mind—that is, one must try to find only what statistics really give, not what one wants to get out of them. If properly applied, this method can either give the law we look for, or show us in what direction we have to look for it, for the underlying philosophical principle is that an effect which recurs with a certain constancy is not due to mere chance, but to some cause which produces it.

The first fact on which weather predictions may be based is that, in general, pressure systems move from west to east. This is especially true for the cyclones and also for the anticyclones in North America and South Africa. For the European anticyclones the question is not so clear. There are exceptions, however. Cyclones are known to move westwards, others are stationary. The next consideration is their rate of displacement. Here we have a less satisfactory state of things. Anticyclones, as a rule, move slowly and hang over the same regions. To the cyclones we can assign an average rate of displacement deduced from a large number of observations. But here the averages are deduced from velocities ranging from zero to a hundred miles or more.

Another important consideration is that of the tracks followed by the various pressure systems. Here we are on still less certain ground. In North America the cyclones and anticyclones follow one another fairly regularly, and move also with a fair regularity along certain mean tracks, which change, however, with the seaons. The same may be said of the tropical cyclones in the West Indies, Mauritius, and the Far East. In Europe, however, it has been practically impossible to find a system of tracks that can be of any great use in weather forecasting. Köppen, Van Bebber, Rykatchew, who especially investigated this point, find from five to ten mean tracks over Europe.

The solution of the pressure transformation has been tried in another way also. From the study of the daily charts a series of weather types has been deduced, and their formation and transformation carefully studied. The possible influence of large areas of heat, rain or snow, on neighbouring pressure systems has been patiently investigated, and rules for forecasting transformations or displacements in these systems deduced therefrom.

When, by some such consideration, the forecaster has decided upon the probable transformation of the existing system of pressure, he has to pass to the transformation of the existing weather. Here, besides the general correspondence of pressure and weather, he has to take into account the seasons of the year, the geographical position of the pressure systems, as well as the position of the localities for which his forecasts are made, in regard to probable tracks of the pressure systems.

A few examples will show how he may apply his knowledge. The pressure chart shows, for instance, to the American forecaster, a depression over Texas with very close isobars in the western half, and a high area over British Columbia. There will, therefore, be a strong movement of air from the front of the anticyclone, where winds are from the north-west, to the rear of the cyclone, where winds are north-westerly also. If this occurs in the winter season, he can with confidence predict a cold wave from the north-west over the Central States, and, as the probable track of the Texan cyclone, as well as its probable rate of displacement, are fairly well known in North America, he can for two or three days beforehand predict a cold wave over the Eastern States. If positions are reversed, in summer for instance, and an anticyclone has persisted for some time over the south-east, Florida, Cuba, etc., he can, if he sees a depression forming in the north-west with a steep gradient, predict for similar reasons a hot wave over the Central States, which will move from east to west, and give notice of it one or two days beforehand. The Californian fruit-grower who has a consignment of fruit on the road to the East can telegraph suitable instructions to his agents along the line for the preservation of his cargo. In the same way a forecaster in Central Europe can foresee floods in the spring when he sees a cyclone coming from the west towards the Alps with close isobars in the front. There will be a strong movement of air from the Alpine region towards the advancing depression. The air, although coming from the cold regions of the Alpine ridge, will, in its descent to the lower levels of the valleys and central plains, become warmer and usually melt, in one day, more snow in the valleys than would be melted in a fortnight under ordinary circumstances. A high barometer over the Sahara and a low barometer over the Mediterranean will, for similar reasons, allow him to forecast the dry hot sirocco over the northern part of Africa. For South Africa Mr. Wood, who is in charge of the Transvaal forecasting service, gives the following typical cases:—There is a low barometer inland, and a high barometer is forming in the west. If this high barometer is off the West Coast, it will, in the course of a day or two, invade the Southern tableland, and form an anticyclone over Bechuanaland, Southern Rhodesia, and the Transvaal, bringing with it the usual anticyclone weather, which for us here means south-east wind, with a period of unpleasant cold weather, followed by some days of fine, dry weather. In summer this invariably breaks up a period of rainy weather in Southern Rhodesia. If the high pressure appears in the south-west of the Cape, it usually skirts around the inland depression, and forms a system of steep gradients from the sea to the land.

In this case in summer we may forecast extensive rains inland. A third common type is the one I have alluded to before. A V-shaped depression appears in the south-west, and gradually sweeps over South Africa from West to East, with a line of duststorms in winter and thunderstorms in summer.

Examples might be multiplied indefinitely. These are, I think, sufficient to show, that although weather forecasting is based on a sound, scientific basis, it is in practice an affair of experience supplemented by that inborn and hardly-acquired gift which in doctors is called the gift of right diagnosis. We may say that, as far as weather predictions are concerned, meteorology is in the position in which medicine was before Pasteur. The wonderful progress of physiology, chemistry, and other sciences in the first half of the nineteenth century had put medicine on a sound, scientific basis. The ailments we are subjected to had been carefully studied and described in their various phases, but when it came to practice it was found that after all a doctor, however well grounded in general knowledge, had to rely mainly on experience, and had to trust a great deal to his gift of intuition. By the discoveries of Pasteur, medicine has made enormous strides forward; it has certainties now where before it had only probabilities, and in many cases can point to 90 and even 99 per cent. of successes, when before the proportion was often reversed. Will meteorology ever find a solution to this problem of the transformation of pressure systems, which, as far as meteorology is a practical science, constitutes its chief end? Some have hopes that the solution is not far off, and that generations to come will find it hard to understand how we could live comfortably without ever being certain of the weather of the morrow. Others are not so sanguine. Professor Pernter, in an address to the Austrian Association for the Advancement of Scientific Knowledge some years ago, said:

> "To predict the weather with certainty is the ultimate aim of meteorological science, but we are at present so far removed from it that we have many well-founded doubts as to whether this object will ever be attained."

In spite of the difficulties inherent in this part of meteorology, the various weather bureaux are fairly successful in their weather forecasts. Their successes vary from 80 to 90 per cent. In some cases they are even more successful. The American Weather Bureau, for instance, can boast that for years no storm struck the East Coast of the States without timely warning of its approach having been given, and—what in some respects is even more important—that for several years no wrong warnings have been given, every storm they had predicted having been courteous enough to keep the appointment.

A new method of weather forecasting has been brought forward within the last few years, and has attracted a great deal of attention. It has its opponents and its sympathisers in meteorological circles. It rests on principles that are most of them new either in substance or in form, and certainly new in the way in which they are applied. It cannot be passed over now, for if it be proved correct, it will certainly be the most important step forward which meteorology has made within the last fifty years. Six years ago the Belgian Meteorological Society organised an international forecasting competition, and offered a substantial prize to any scientist who could bring some notable improvement to the methods then in use for weather predictions. The conditions imposed by the Society were such as to exclude all weather quacks, for the question was practically restricted to the following: Predict from given weather charts the barometric variations over the whole of Europe for the next twenty-four hours, the path of the depressions, the birth and dislocation of cyclones and anticyclones. The candidates had besides to write a memoir explaining their method of forecasting. Some of the leading meteorologists of the day, Lawrence Rotch, Teisserenc de Bort, Dr. Polis, Professor Brunhes, consented to be on the Board of Examiners. The jury unanimously awarded the prize to Mr. Gabriel Guilbert, the secretary of the Meteorological Society of Caen in Normandy, because, as Professor Brunhes pointed out in his report:

"The method this gentleman employs enables him to foresee with precision the displacement and variations for the centres of high and low pressures over Europe. Although this method does not give us an absolute certainty, it has been efficient in forecasting complete transformations which no other method so far has been able to predict."

Professor Brunhes has since taken up this question theoretically, and shown that this method was in accordance with the theory of vortices as expounded by Helmholtz, Kelvin, and Bjerknes. He even confirmed his deductions by a series of very neat laboratory experiments.

I can give only a brief outline of the method. The fundamental idea is that the surface winds alone have a decisive influence on the variations of barometric pressure. Neither temperatures, nor areas of precipitation, nor geographical configurations, have to be taken into account. The chief points to be considered on a weather map for predicting pressure variations for the next twenty-four hours are those where the winds are "abnormal." To grasp the method we must consider what the author understands by abnormal winds. We have seen already that there is a normal system of wind circulation round the areas of high or low pressures. Considering the northern hemisphere only, since the author has so far applied his theory to European weather only, we have, if we go from west to east through the south round a cyclonic area, the following sequence: North-west winds in the rear, then west, south-west, south and south-east in the front. In an anticyclone the sequence would be reversed: we would start with south-east in the rear, to end with north-west in the front after passing through south, south-west, and west. Any wind direction differing from these will be more or less abnormal according to the degree of divergence.

The winds may be abnormal also in strength or velocity. I have mentioned before that there exists an evident relation between the force of the wind and the closeness of the isobars. To get an idea of this relation, we must have some means of measuring the force of the wind on the one hand and the degree of closeness of the isobars on the other. The force of the wind on the weather charts is generally estimated on a scale (the Beaufort scale) ranging from 0 to 10, 0 standing for calm and 10 for hurricane winds. The degree of closeness of the isobars is measured by the barometric gradient. If the distance between isobars drawn through points which differ by one millimeter in pressure is 60 geographical miles, the gradient is 1, if the isobars are twice closer the gradient is 2, and so on. From the analysis of a vast number of observations meteorologists have found that on the West Coast of Europe the normal wind for a given gradient is denoted on the Beaufort scale by a number which is twice the gradient; a gradient 2, for instance, gives normally rise to a wind force of 4, a gradient 3 to a wind force of 6, etc. Wind forces differing from this proportion are, according to Mr. Guilbert's way of speaking, abnormal, either by excess or by deficiency, as the case may be.

Mr. Guilbert's rules, twenty-five in number, may all be derived from the following, which may be said to be absolutely new. If in a depression we have winds abnormal in excess with regard to the gradient, the winds will produce a rise in the pressure, the propagation of the rise being from the right to the left. (In the southern hemisphere, of course, the propagation would be from left to right.) In other words, put your back to the wind that is proportionally too strong, and you will find the high pressures gradually encroaching on the low pressures from right to left. If this principle be correct, and Mr. Brunhes's investigations lead us to consider it so, we have a most important principle for solving problems of pressure transformation. Take, for instance the case where, on going all round a depression, we find everywhere winds too strong in proportion to the gradient. In this case the pressure will rise everywhere from right to left—that is, towards the centre, the depression will be filled up in a short time, and be replaced by a high-pressure system, explaining thus the puzzling phenomena of the sudden vanishing of a storm area and the substitution of a fine weather system.

A cyclone has, generally, a more complex system of wind circulation. If at one point we have winds abnormally strong, we have usually also at others winds abnormally weak. In this case the cyclone will deepen and move on towards the regions of least resistance. Regions of least resistance are precisely those where the winds are abnormal by deficiency, and more especially those where the winds are abnormal in direction.

If we apply these rules to some weather charts, we cannot fail to remark that they certainly answer in many puzzling cases. Abercromby, among the various weather types which he examines in his book on the " Weather," mentions one which is the despair of the forecaster in Western Europe. It is the one in which cyclones seem to hang over England, producing violent easterly gales, and are finally dislocated or driven westwards. He gives a series of weather charts for four consecutive days to illustrate this weather type. If we examine them in the light of these rules, we see that the pressure sequence can be explained, and that the stationary character of these cyclones or their drift westwards could be foreseen. In his maps a group of depressions hangs over Western Europe extending from the Baltic to the Azores. In front of this cyclonic area there is an anticyclone over Scandinavia in the rear, and an anticyclone over the Mid-Atlantic. The winds in front of the cyclone are south-east; so are also those in the rear of the Scandinavian anticyclone. The cyclone is therefore in contact with a part of the anticyclone where the winds are normal in direction in regard to cyclonic circulation; the cyclone finds, therefore, in that region a barrier to further progress. This combination is likely to produce a wind force larger than the normal. Abercromby gives no indication about the force of the wind on his charts, but he mentions that this type of weather gives very violent gales over the East of England. If we put our back to the south-east wind over the North Sea, we see that, according to Guilbert's rules, the Scandinavian anticyclone is to encroach on the cyclone and drive it westwards. A similar reasoning would show that the anticyclone of the Azores would encroach from the south-west to the north-west. The cyclone is, therefore, wedged in between these two anticyclones, and obliged to be stationary and undergo gradual compression—a process which can be clearly followed on the charts given by Abercromby.

Whatever may be the value of these rules for general forecasting, it seems certain that they may be used with great advantage in countries which are subject to sudden storms that cannot be forecasted owing to the lack of communication with the regions where they originate. Mr. Guilbert has given many instances of storms which have burst upon Europe and caught all the meteorological offices unawares. He had a little prediction service of his own for the use of the members of the meteorological society of which he is secretary. He has produced authentic documents to prove that in his forecasts he has predicted storms, and even given to the millimeter the drop of the barometer, in cases where official meteorology had been altogether at fault. The sudden storm which burst upon Western Europe on the 12th of March of this year gives a good illustration of this. On the weather map of March 12th, at 9 a.m., we have two cyclones with feeble gradients, one off the coast of Scandinavia and one over the Bay of Biscay. The wind system of the West of Europe is regulated by these two cyclones. There is no indication that a serious depression is forming over the ocean. If a depression the centre of which would be over the Channel within twelve hours were in the west, in ordinary circumstances, all the barometers on the west coast would have been falling rapidly during the night. The only one which showed a fall of a quarter of an inch was that at Valentia. The winds of the West of Europe would, in ordinary circumstances, have been already for some time regulated by the coming cyclone, and would have ranged from south-west to east, being winds belonging to the front of a cyclone. On the contrary, they were practically all different from the directions they ought to have, as they mostly ranged from north to north-west. They were therefore strongly abnormal with regard to the coming cyclone, and there was nothing to indicate a coming storm, and no meteorological office gave warning; yet before night a terrific storm had burst upon the West of Europe.

Applying Guilbert's rules, we find that the fall of the barometer at Valentia, which indicated the existence of a depression over the Atlantic in the west, was sufficient to show that a serious storm was likely to burst over Western Europe. For this depression had in front of it nothing but winds that were strongly abnormal; it would, therefore, deepen rapidly and progress with great velocity as it found no resistance in front of it. The track it would follow would be along the line of junction over the two existing cyclones—the one off the Scandinavian coast, the other over the Bay of Biscay—as that would be a line of weakness. That this is a line of weakness is a clear deduction from Mr. Guilbert's theory of the abnormal winds. Along such a line the winds generally diverge from one another, as one set belongs to one part of the cyclone A, and the other set to the opposite part of the cyclone B, and both sets of winds will be abnormal in regard to the coming cyclone. On the map of the 12th March this line of diverging winds was clearly shown to pass from the entrance of the Channel through North-Eastern France into Belgium. This, therefore, is the line which the centre of the coming cyclone would follow. In its course it would absorb the two existing cyclones, and the depth of the new depression would be, at least, equal to the sum of the depths of the component cyclones. This is exactly what happened. The cyclone passed over the Scilly Islands on the afternoon of the 12th, and was over Brussels on the morning of the 13th. The barometer had dropped 25 mm. since the preceding day. The velocity of its translation must have been over 1,000 miles in twenty-four hours, about three times the average velocity; its violence was unusual, as winds of over sixty miles an hour were registered in Paris during its progress. The two other depressions had been absorbed.

This method has been carefully discussed by some of the leading meteorologists of the day. The principle of the normal wind is accepted as without doubt correct by Nils Elkolm and Köppen, as far, at least, as fast moving cyclones are concerned. It seems to me, however, that in the application of the normal wind there lies a real practical difficulty. The figures agreed upon as representing the normal wind for a certain gradient are far from representing the exact value of the normal wind. This value has not been derived from theory, but from the discussion of a vast amount of statistics. But the discussion of the statistics shows that this value can only be taken as a general guide, and cannot be taken as the basis of very exact determinations. For we get different values and sometimes vastly different values, for the normal wind in different quadrants of a cyclone, for different seasons, and very different values also for the high seas, the coastal regions, and the mainland. From the figures given by Loomis I suspect that we will also find very different values for the normal wind for a given gradient in cyclones and anticyclones. It seems, therefore, that the judgment of the normal wind is largely an affair of experience, and that the application of these rules will take time. It is particularly difficult to apply them where investigations bearing on the normal wind have not been made. Hitherto such investigations have been mainly confined to Europe. Clement Ley, Sprung, Köppen, Kassner, and others have analysed a vast amount of data, but it cannot be said that the results they arrived at are sufficiently uniform to allow a purely mechanical application of Mr. Guilbert's system. Time will prove whether this system can do all that it claims, but whatever may be the ultimate result, from what I have said it seems evident that it deserves careful consideration.

Whatever method be adopted, it is clear that weather forecasting, to be efficient, can be undertaken only by a central organisation which can control observations over a large area. Let us hope that the time is not far off when South Africa also will have a Weather Bureau to centralise the observations taken in as many stations as possible south of the Equator. The most certain fact in South African weather conditions is the general progression of pressure systems from west to east. At the present moment the western half of South Africa is really a "dark continent" as regards meteorology, and we know scarcely anything as to weather changes taking place there. The South African weather problem will never be solved with such an unknown region lying to our west. We must be able to connect up movements of the barometer at Swakopmund and Port Nolloth with subsequent movements at Kimberley and Bloemfontein, and to this end there must be a chain of stations across the continent. This is, perhaps, according to the experience of the Transvaal forecasting department, the most important need in South African meteorology at the present moment.

Nor is it for the success of weather forecasting only that a central meteorological office is greatly needed for South Africa, but even more for the progress of the general meteorology of this sub-continent. Individual investigators have done great work in meteorology during the last century, but they would have done very little if the material on which they mostly worked had not been collected and prepared for discussion by the various central meteorological offices. There are many problems in the South African weather which await solution, and which have not even been tackled. Yet their solution would be of great economic value to South Africa. We have read lately in the press of a controversy in political circles on the expediency or inexpediency of encouraging emigration to South Africa. The political side of the question does not come within the scope of Section A, but there are other sides to the question. If immigration is to help us to make South Africa one of the great nations of the Southern Hemisphere, we must expect that the stream of immigrants will be directed towards the vast tenantless hinterland in which, according to Rhodes, lies the future of South Africa. You have come through a great part of this hinterland. From the Vaal River to Bulawayo you have come through 700 miles of it; to the Zambesi you will travel through another 300 miles of it. In this long stretch of 1,000 miles you do not see a drop of water, and you might go miles east or miles west and find practically the same state of things. We hope to see one day a prosperous population along this branch of the Cape to Cairo line, but meanwhile we must not forget that many a farmer has been ruined and nearly starved on farms averaging from five to ten square miles in this very hinterland through which the railway passes, and that because the farmer's chief enemy in Central South Africa is the climate. For six months or more he can do next to nothing; the climate renders his efforts practically useless. The earth does not under our sky recuperate its strength during the winter months, absorb moisture, store it up to have it ready for useful work at the dawn of spring. No, for six months it undergoes an uninterrupted process of exhaustion, and when our spring comes there is in the greater part of the hinterland no apparent trace of moisture left in the soil for several feet below the root level of the yearly plants, often not even on the banks of what on the maps are marked as rivers. The farmer has to make his living and his profits out of the five or six rainy months. And what can he be told about this season? He can be told that he may on an average expect 25 inches of rain during the season, but that this may mean anything between 12 and 35 in the same region. And if he asks what he may reckon on for this season, he must be told that nobody can know. He may be told that the rains may be expected to start at the end of October, but he must be warned, at the same time, that years have been known with no useful rains before December, January, and even

February. He may be told that he must expect spells of drought, more especially towards the middle of the season, but that they have been known to occur at any time during the season, and that they may last anything from a fortnight to six weeks. If these vague indications do not seem of any great use to him, he can only be told that his questions suppose that we know something definite about the conditions which govern South African weather—conditions about which we know very little and about which we shall go on knowing nothing or next to nothing as long as the South African Governments do not give us a central meteorological organisation that controls observations over as large an area as possible, over the whole of the Southern continent if possible, for the laws that govern our climate know of no political boundaries. The Indian Meteorological Service for its monsoon forecasts has to study the weather conditions not only of India, but also of Siberia, Egypt, Mauritius, South Africa, and even of its antipodes, South America.

A start in the right direction was made by the Transvaal Government after the War, and the Responsible Government that succeeded intelligently promoted what had been begun before. Are they going to extend to the rest of South Africa the benefit of what they have done in the Transvaal now that their sphere of influence has extended over a large part of the sub-continent? It is to be hoped that in this matter they break away from the traditions of the former Governments, who seemed to have looked upon the study of South African weather as useless, or at most as a scientific hobby which had to be encouraged a little, apparently because the Governments of the old world, for some unknown reason, chose to do so. Our cousins across the North Atlantic have the reputation, merited or not, of judging everything by its money-producing value. The American Government maintains the most perfect meteorological organisation in existence. It is one of the great departments of the Federal Government. The Central Weather Bureau in Washington, magnificently equipped, staffed by a small army of over 200 officials, controls some 200 meteorological offices with 900 auxiliary stations. Its staff of paid officials is over 1,600 strong, and is supplemented by several thousand voluntary observers, who bring the numerical strength of the Bureau to something over 7,000. In salaries alone the expenditure exceeds £300,000 a year. At the same moment every morning—that is, at 8 o'clock of the 75th Meridian time, which means 8 on the east coast and 5 on the Pacific coast—observations are taken at some 200 stations, and telegraphed at once to Washington. As these messages are privileged messages on the wires, they are all handed in at the Weather Bureau by half-past eight. The data are classified and charted at once in half a dozen different ways, and before half-past ten, as a rule, the forecasts for the next twenty-four or thirty-six hours are made, and the daily weather charts with the forecasts printed are ready for distribution. The number of post offices or addresses receiving in 1907 a daily report by mail direct from the central office was 78,109, and the grand total of addresses to which daily forecasts were sent through the offices which the Washington Bureau controls was 2,141,151, and that independently of the people who were reached by the newspapers, which most of them publish the daily forecasts of the Weather Bureau. Thousands of weather telegrams are sent daily at Government expense, for the telegraph lines in the States belong to private companies. Railway companies have special code signals affixed to the guards' vans, special alphabet of locomotive whistles, that people in the country districts may see or hear the weather report as the train rushes by; thousands of telephone companies receive a daily weather telegram, the contents of which they telephone at stated hours to all their subscribers, and I don't know how many other means are used, or have been tried, to disseminate these forecasts daily through the most inaccessible parts of the Union. If the hard-headed American politician, if railway, telegraph, and telephone companies, if farmers in the prairies of the Far West take this daily interest in the work of the U.S. Weather Bureau merely to encourage a hobby of a dozen scientists in Washington, we must admit that the average American is a strange being, stranger even than the conventional American of the European novelist.

Meanwhile, whatever others may think or do or not do, the American statesman is fully aware of the great benefits his country derives from the Weather Bureau. He sees that, owing to the intelligent support of its government, the Bureau is able to-day, to mention one only of its numerous works of public utility, to predict the river floods days and even weeks in advance, give the rise of the water in various parts of the river course to the nearest foot; that the value of property thus saved every year often by one single prediction represents several times over the whole appropriation for the meteorological service. The farmer in the dry lands of the West knows, or may know if he cares to inquire, that it is owing a great deal to the practical interest which his Government takes in the work of the American scientist that he can even to-day land his maize at any South African port as cheap, and often cheaper, than the farmer in a great part of the South African hinterland can land his at his nearest railway station.

Section B.—CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.

President of the Section.—A. J. C. Molyneux, F.G.S., F.R.G.S.

THURSDAY, JULY 6.

The President delivered the following address:—

SOME PROBLEMS PRESENTED BY THE KARROO SYSTEM IN RHODESIA*.

In considering the subject for the address that is expected of me as President of this section, I am somewhat daunted by the variety of the sciences that it embraces—matters that are of no little interest in a country such as Rhodesia, where geographers of classic renown have mapped and hunted, where the rock structure has so much to do with the distribution of its metals, industries and farming, and where the complex problems of its ore deposits demand the continued research of the metallurgist and chemist.

Where we may have seen some apparent incongruity in the grouping of the section, it becomes compatible if we sub-divide it into two groups. In the objects of one, geographical and geological research become condensed into that of a science which deals with the apportionment of the matter which makes up the face of the earth and the distribution of the veil of vegetation and its inhabitants, while in the other we attempt the analysis of such matter, or the reduction of its accessory minerals and ores so that they may be of benefit to mankind.

At this Congress, where, besides the discussion of general science, there is a desire to learn something of and consider the features of the country that is being visited, it may not be surprising if my address flavours of Rhodesia, and if I therein treat my subject as it affects, or is influenced by, this part of South Africa.

A general summary of the discoveries and results of the year made by workers in those sciences of which we are the foster section I do not propose to attempt—partly because it would be impossible to do justice to even the research of South Africans, and also for the reason that each of the sciences

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* References: "Catalogue of the *Glossopteris* Flora" (British Museum, 1905): E. A. Newell Arber. "The Face of the Earth": Suess; Sollas's translation. Geology of the Cape Colony." 1909: Rogers and Du Toit, and the chapter therein on the "Reptiles of the Karroo," by R. Broom. Dana's "Text-Book of Geology". Dr. D. Mawson on the objects of the proposed Australian Antarctic Expedition, in the *Geographical Journal* of June, 1911.

embraced has its own wealth of journals that distribute such knowledge periodically.

My work, for many years past, has led me into those distant parts of the country in which occur large terrains of rocks of the Karroo System and their associated coal deposits—areas that make up nearly one-third of the whole of Southern Rhodesia. In these solitudes the geological problems that are suggested by the mountain ranges, river gorges and rolling plains of the varied scenery constantly appeal to one's reasoning powers, and it is to some of these problems that I wish to draw your attention to-day.

I should like, at the outset, to deal with two matters that are appropriate to the subject of my address, the first being the establishment, in Rhodesia, of a geological survey, and the provision for similar field work in the Mozambique province of Portuguese East Africa. Nyassaland has already been geologically mapped by Messrs. Andrew and Bailey in 1908, while, thanks to Mr. F. E. Studt, the rock systems of the Katanga or south-east corner of the Congo State have been worked out in much detail.

Important geological research is thus being extended around us, and soon we may hope to understand the intricacies of the metamorphic rocks and their relationship to those of the neighbouring states. Rhodesia is to be congratulated on obtaining the services of Mr. H. B. Maufe as the Director of its Survey, for his research among the archæan rocks and work on the Geological Survey of Scotland, and his experience of African conditions in Uganda, stamp him as one thoroughly capable of handling the problems of Rhodesian geology.

As geographers we are probably giving some attention to what has inaptly been called the "race for the South Pole," now in full gallop. Within the Antarctic Circle, partly walled in by an almost continuous barrier of ice, lies a great land mass of elevated plateaux of an area of some 5,000,000 square miles. With the discovery of the North Pole Arctic exploration lost much of its relish, and noted leaders are now engaged in attempts to reach the centre of the southern continent. By some arrangement this was divided into four, Captain Scott being allotted the Victoria Quadrant, or from 90° to 180° East Longitude, the Germans taking those east and west of the Greenwich Meridian, known as the Enderby and Weddell Quadrants. Dr. Mawson's projected Australian Antarctic Expedition will also operate in Scott's quadrant.

Captain Scott has already arrived at Cape Evans and established winter quarters there.

Depôts are now being laid down by him along the land route for use in the great attempt to reach the Pole next summer. These results we cannot hear until well into our next winter, yet we may feel assured that every resource of the gallant party will be taxed in order to secure success. The German ship

Deutschland, with the party which Lieutenant Filchner will command, left Bremerhaven on the 8th May, and will proceed, *via* Buenos Aires, to its allotted sphere of exploration.

It must have been with no small surprise that Captain Scott, who, when he left Europe, had heard of the preparations for another North Polar Expedition, under Captain Amundsen, found the latter's ship, the *Fram*, going into winter quarters in the Bay of Whales, not far from his own base. Amundsen has explained that the change of plans was due to the discovery of the North Pole by Commander Peary, "which spelt ruin to his own undertaking," and that he made up his mind in September, 1909, to undertake the only problem left—to reach the South Pole.

One cannot help thinking that Antarctic research has more to attempt than the one sublime idea of the Pole, and that, with so much of the conditions of that continent unknown, Amundsen's undoubted energies might have attacked some other part of the coast. Still, as the President of the Royal Geographical Society has so well said, "no explorer obtains any vested right merely by exploration," and we should, in our desire for knowledge, welcome all who care to seek.

Dr. Douglas Mawson's project is one that is greatly appealing to the people of Australia and New Zealand, for less than 1,200 miles separates them from the new continent, and the climatic, geological and geographical conditions of such near neighbours must have much in common. The expedition is now being equipped in London, and assumes a national aspect, as its scientific *personnel* will be chiefly recruited from the Universities of Australasia. It will explore the great coastline of 2,000 miles between Cape Adare and Gaussberg, and it hopes to have permission to add that portion of the new continent opposite Australia to the Empire.

No less than in benefiting Australia, many problems of meteorology, physics, biology and geology will be clarified by a greater knowledge of this great neighbouring land mass, and as scientists we shall await the results of one and all of the explorers with interest and admiration at their intrepidity. The influence of such research on South African geology I refer to in a later part of my address, and it is for this reason that I have sketched the plans of the various expeditions now engaged in Antarctic exploration.

The Karroo System.

I shall now return to the subject proper of my address. The Karroo system occupies all the central elevated plateaux of Cape Colony, the Free State and Basutoland, and high veld areas occur in Natal, the Transvaal and Bechuanaland.

In Rhodesia areas of these rocks occur in the low-lying valley of the Limpopo and the middle Sabi river. Karroo lavas are to be seen near Charter. The largest terrain is that of the middle Zambesi valley, with branches up the Luangwa and

Lusenfwa valleys. Outposts and outliers are presented by small patches on the Northern Rhodesian plateau, in the hook of the Kafue, and, still further north, Mr. Studt maps another on the Lualaba in the Katanga region of the Congo.

As it now remains, the system here is represented by vestiges of a previously widely-extended distribution, and there is no doubt that it formed part of that great and ancient continent of Gondwanaland, that is now partly lost under the waters of the Indian and South Atlantic Oceans, but whose boundaries included the whole of Australia, Borneo, India, East and South Africa, and the Argentine Republic of South America. It is significant to add that the small areas on the Kafue and Lualaba suggest a further extension of the boundaries of the ancient continent, and Mr. Studt describes so well the great escarpments that face the Congo Basin (a feature of some similarity to the Drakensberg that faces the Indian Ocean) that it may be found that region is but another partly depressed area of Karroo rocks, and that the northern boundary crossed Africa to include the Congo, and so across the Atlantic to Brazil. Of its southern extension none can say at present, but we look to the geologists of the South Polar expeditions to say if the coal known to exist in Antarctica was due to the same continental flora, and whether that great land mass may be considered as another province of Gondwanaland.

In Permo-Carboniferous times there were two great land masses in the world almost completely separated from each other. The southern, in which the *Glossopteris* flora grew and flourished as a vegetation, distinct from the northern, was named by Suess Gondwanaland, parts of which I have already referred to. The term is derived from the great series of fresh-water sediments in India to which Medlicott gave the name of Gondwana.

The long chain of reasoning by which this ancient continent was discovered, and by which we know something of its boundaries and physiography, mountains and lakes and deserts, weird animals and jungle growth, glaciers and climate, is one of the most remarkable triumphs of geological research.

Investigators in each of the provinces named had found that certain rocks there contained fossils of the fern-like plants of the *Glossopteris* flora, an assemblage of plants of distinct characteristics, and remarkably different to the Carboniferous flora of the Northern Hemisphere. Brongniart described the first from India in 1828, and recognised similar species among fossils that had been sent from Australia. Feismantel in 1876 entered the field, and from that time until 1890 described specimens from India, New South Wales, Victoria, Tasmania, and published his monumental work on the Gondwana flora. The correlation of the beds of these regions was thus recognised, and the *Glossopteris*-bearing rocks received much attention, as Mr. Newell Arber's list of literature will show.

Further evidence was apparent in the discovery of remarkable boulder deposits at the base of these sediments in Australia and India, now known to be the result of glaciation. This was confirmation rather by reason of similar conditions of deposition, but the idea that they originated in a common continental mass also took root, and "helped materially in the correlation of the rocks" of the two provinces.

It was, however, some years before the actual horizon of *Glossopteris*-bearing beds could be correctly placed in the geological record. The remarkable difference to the plants of the north led to the belief that this flora was of a later period of development, and leading investigators assigned to it an age as late as Jurassic. But by a study of the fossils of a marine incursion into the Muree series in New South Wales (comparable with our Dwyka period), and the recognition by means of its carboniferous mollusca, some early *Glossopteris*-carrying beds were placed as Carboniferous. In India, also, marine beds of Permian and Upper Carboniferous age overlie the basal boulder beds.

The *Glossopteris* flora has thus been assigned to the Permo-Carboniferous period—a correlation borne out by its mollusca, crustacea, fish and other fossil remains.

Meanwhile South African geologists were at work, and Rubidge in 1859 first discovered specimens of the same flora at Bloemkop, which he compared with those occurring in India. Discoveries of other species followed which were identified by such noted botanists as Tate, Griesbach, Zeiller and Feismantel. Correlation was thus established with the systems of the Indian and Australian, and recognised by Stow, our distinguished geologist, who wrote in 1871 a paper "On the Probable Existence of an Ancient Southern Continent."

As in India and Australia, South Africa has deposits at the base of its Karroo that occur in a very similar position with regard to the *Glossopteris*-bearing beds, and a recognition of the glacial origin of the Dwyka Conglomerate is further evidence of the widespread land conditions found in the three continents.

Discoveries of areas of rocks of the Karroo system, with fossils peculiar to that age (found by Penning, 1884, and other evidence due to Mr. Leslie's keenness and Mr. Seward's identification), led to the inclusion of the Transvaal, Rhodesia in 1903, Tete on the Zambesi (described by Zeiller in 1883, who also drew attention to the northern type existing in this locality), and German East Africa and the Portuguese Provinces. Messrs. Andrew and Bailey give evidence that causes the inclusion of Nyassaland.

From Brazil and the Argentine specimens were obtained that led to the inclusion of a portion of South America as a province of the ancient continent. In 1891 Hettner announced the discovery of representatives of the *Glossopteris* flora, and

Zeiller in 1895 pointed out their identity with members of the same flora in India, and also that:

"there is a remarkable association in Brazil, of such typical members of the *Glossopteris* flora as *Gangamopteris* and *Neuropteridium* with a common Upper Carboniferous plant of the Northern Hemisphere *Lepidophoios laricinus*"

the significance of which will be dealt with later.

In South Africa deposits that are homotaxial with similar beds in India and Australia are widely developed in the Karroo, which gives a name to the system in this part of the world. The maximum thickness in the Cape Colony is given by Dr. Rogers as 15,000 feet, including the volcanic beds outpoured during the concluding phase of the Karroo system.

Compared with the periodic arrangement of the Northern Hemisphere, deposits began to accumulate in Upper Carboniferous times, were gaining in thickness during the whole of the Permian, covered the Rhætic, and closed in Lower Jurassic times: the Karroo age thus embracing several of the periods of the northern world, and shewing it to be of great duration in time, Professor R. Broom estimating it at two million years.

What of the floor upon which the Gondwana continent was built up? It varies much in structure from the Cape coast to the Zambesi, and while in the former locality there are older formations that have been investigated by Dr. Rogers and the members of the Cape Survey, in Rhodesia we have not yet worked out the component systems of the great mass of pre-Karroo rocks—a problem that awaits elucidation. Some masses are metamorphic and folded, others shew no sign of alteration, but between their deposition and the oncoming of the lowest Karroo rocks there is a bridge that may span many chapters of the geological record. There is no evidence to show that Rhodesia had been submerged under the ocean since remote geological periods, and even the deposition of the Karroo beds on its surface does not imply a reduction to sea-level, but rather continental conditions. The antiquity of this part of the continent is therefore extreme.

The geology of the Cape Colony affords some light on this subject*. During the early Palæozoic times marine conditions prevailed over the southern portion, but the connection with the ocean became cut off, the water shallowing to receive the sediments of the Witteberg and the lowest strata of the Dwyka conformably. Gradually the land rose from the level of the barricaded ocean for the last time after the oscillations of previous ages.

This emergence was probably due to a spreading elevation of the Antarctic Continent to embrace the area of the South Atlantic Ocean, Australia, the Indian Ocean and the Cape. In the latter area the land, after emergence, formed a great inland basin or lake. Mountain ranges existed beyond the Orange

* See "The Geology of the Cape Colony," Rogers and Du Toit, 1909.

River, and perhaps elsewhere, towards Rhodesia. A geographical change like this, Dana thought, would certainly bring about a refrigeration of the climates of the continent, and thus affect a very large part of the earth's surface. Ice sheets resulted, and from these snow-clad regions glaciers brought down the boulders and mud to form the Dwyka conglomerate. These gradually filled the deepest depression in the south-west of the Cape Colony to a thickness of 1,000 feet of glacial debris.

Glacial striæ show that this came from the great areas of pre-Karroo rocks in the north, and it is possible that high plateaux, long raised from sea-level, existed in this direction, and would be planed down by the action of the ice. How far north this snow-sheet extended is hard to determine in the absence of evidence of glaciation, and the answer may be found in North-Western Rhodesia.

The present configuration of that province suggests some such planing action in early Karroo times. The landscape that resulted was much as we now find it there—wide rolling plains, dotted by isolated hills of 200 feet in height, flat distant horizons, and sluggish rivers. There is good reason for believing that much of that country was afterwards covered by some one or other member of the Karroo deposits, that have since and comparatively lately been removed by denudation.

The growth of Gondwanaland commenced with an accumulation of great boulders of the contiguous rock masses. Glacial origin is assigned to these deposits in the Cape Colony and Transvaal (Dwyka), and to those in lower Talchir stage in India, the conglomerate in Queensland, Tasmania, West Australia, and at the base of the Muree Series in New South Wales, the Bacchus Marsh boulder beds in Victoria, the Orleans conglomerate of the corresponding Santa Catherine system in Brazil, and the Falkland Islands, all showing how widespread were the causes of ice movement. Boulder beds occur in a corresponding position in the Karroo beds in North-Western Rhodesia and North-Eastern Rhodesia, among which there is so far no definite evidence of glacification, but they point to an origin in storm deposits, screes and surface litter among hilly regions.

The conditions which followed led to the accumulation of the Beaufort beds, of coarse sandstone, as storm deposits, then the Stormberg series of fine sandstone and shale. The highest series is the Volcanic, forming the flat tops of the mountains, and reaching as great a thickness as 4,500 feet in Basutoland, sometimes interbedded with sandstones and tuffs.

Here again is a coincidence with other Provinces of the continent, for volcanic rocks now form the summit of the system in Brazil, Rhodesia and India—the Deccan trap.

It is surmised from an examination of the grains of the forest sandstones in Rhodesia that desert or sterile conditions occurred towards the close of the age. Some of these beds are remarkably fine, and resemble marls, though they are highly siliceous. As a consequence the overflowing lava sheets converted them into vitreous quartzites containing agates and chalcedony in geodes. Pipes and kernels are numerous under the effusions, and at Tabas Induna a root-like silicification, some 14 inches long, now in the Bulawayo Museum, suggests tree life and a land surface. The frequency of silicified wood-branches and tree-trunks among unaltered sandstones points to hydrothermal action originated by the lava flows, for the vegetable tissue would be decomposed and replaced by heated siliceous waters. Flinty fossil casts of the shells of limnea and other land gastropods have been found among sandstones, but whether these were buried at the time of deposition, or lived recently and became buried in surface sand, since indurated, is a matter that requires some further attention.

The silicification of all remains of organic origin may lead to the discovery of remains of reptiles in Rhodesia such as are found on the Karroo.

During the middle Karroo period earth movements began.

To the south-east of the coast monoclinal bends, which Suess thought were great fault deplacements—especially the scarp of the Drakensberg, which he considered as the fractured edge of a tableland—have resulted in a considerable region of the rocks that were formed in the Karroo basin being immersed under the ocean. In the Transvaal the Karroo strata east of the great axis are bent in a flexure down from the plateau altitude to nearly sea-level. West of this axis or on the continental side the strata remain horizontal, and rest as a transgression on the rocks of older formations.

In construction, flora and fauna of the Karroo basin, and in the breaking down of its southern edge, Suess saw an undeniable resemblance to the Indian peninsula, and thought that, with Madagascar, they bear in common the stamp of a once continuous tableland.

The movements of the crust in the south seem to have been confined to folds along the margins of the axis—in Rhodesia we have a series of great fault deplacements that have let down areas of the Karroo into trenches in the older gneiss. The Luangwa river runs in a canal-like cavity of some 500 miles long by 30 miles broad, the floor being of Karroo rocks, which probably rested on the plateau to the south-east, but were turned over its edge and cut off abruptly by the Machinga fault of at least 5,000 feet and 500 miles long. A similar occurrence has preserved the Lusenfwa valley. The Zambesi's middle course runs along the axis of the extension of the Dekka fault.

Nearer the backbone of Africa, and in Nyassaland, are many small patches of Karroo rocks faulted or bent down into cavities among the older rocks, by which means they have been preserved from denudation. The narrow lakes Nyassa and Tanganyika lie between parallel trough faults that have let down the included portion. This feature is common in India, where a great denudation took place after these movements.

To the north-west lie masses of grit, and their western limit forms a great escarpment overlooking the Congo basin. It thus leads to the extension of the continental area much further west than anticipated. It repeats in a remarkable way the rift faults and depressions of India and East Africa, and suggests some explanation of the low-lying Congo basin and its connection with Brazil.

THE PROBLEM OF THE FLORA.

As the remarkable nature of the fossil flora of the period under criticism was the means of arriving at a correlation of the strata of such distant parts of the world, and as its distribution suggests problems of ancient geography that yet require elucidation, it is advisable to offer a short description of the *Glossopteris* flora of Gondwanaland. From Mr. Newell Arber's work* I extract somewhat freely.

The early primary formations of the world show no fossil plant remains—probably on account of the minuteness and fragile nature of the first forms of vegetation, and also owing to the alteration of the enclosing sediments. In Silurian age occur the earliest known fossil plants, which were the precursors of the Devonian and Lower Carboniferous flora, the latter characterised by remarkable uniformity throughout the world, even including some of the regions that subsequently developed *Glossopteris*.

In the succeeding Permo-Carboniferous deposits are found plant remains that belong to another vegetable epoch, yet divided into two well-marked botanical provinces, one existing in Europe, North America, and North Asia contemporaneously with a dissimilar type confined for the most part to India and the parts of the Southern Hemisphere already alluded to, Australia, South America, South, and we may now add Central, Africa.

"The flora of this province differed remarkably from that of the northern province, and it is now generally accepted that these two types of Permo-Carboniferous vegetation flourished on two great continental regions for the most part, but not entirely, isolated and widely separated from each other."†

The Gondwanaland plants are characterised by the frequent occurrence of *Glossopteris*—a fern-like plant from which the flora takes its name.

The Lower Carboniferous and Devonian flora consisted of the representatives of six great groups—Equisetales (including Horsetails, and Calamites) and Lycopods (with the club mosses, *Sigillaria*, etc.), the Sphenophyllales and Cordaitales, both of which have been long extinct, and the fern-like plants Filicales (true ferns) and Pteridospermæ, which are numerous.

In Upper Carboniferous and Permian times the same six groups were still dominant, whether in the north or south continents, but three new groups made their first appearance—viz.,

* 'The *Glossopteris* Flora," British Museum Catalogue: E. A. Newell Arber. 1905.

† Newell Arber, *op. cit.*, p. xvii.

the Cycadophyta, including the modern Cycads, the Coniferales and the Ginkgoales; but they did not become important, being overshadowed by the six ancient types.

The difference between Permo-Carboniferous and the older flora does not lie in the types or *classes* of plants represented by each, which are the same. The chief contrast

"lies essentially in the Fern-like plants, whether they be true Ferns or Cycado-filices, in the members of the class Equisetales, as well as in the absence of indigenous representatives of certain groups."

To particularise: Among the Equisetales, *Calamites* do not belong to the flora of Gondwanaland; there are, in place thereof, *Schizoneura* and *Phyllotheca*. The latter is found in all four provinces of the ancient continent, and would seem to have originated in Australia, and subsequently spread to India and South Africa and even beyond the boundaries of Gondwanaland into Asia Minor and Russia.

Schizoneura is of a more distinct type, and grew commonly in India, rarely in Australia, is represented in South Africa, and has not been found in South America. Contrary to *Phyllotheca*, *Schizoneura* thus originated in India and later spread to more distant regions. In Triasso-Rhætic times it had spread beyond the limits of Gondwanaland to Europe and parts of Asia.

An equally important plant is one among the Sphenophyllales —*S. speciosum*, which is more of a northern type, and its presence in India and absence in Australia point to a migration from the northern continent of the period, with which there was probably land connection between Europe and South Africa, as the emigration of the Equisitales would also show.

Of the Filicales, *Glossopteris*, the typical and peculiar genus of the Gondwanaland flora, flourished abundantly everywhere. *Gangomopteris* is another genus, and both travelled along the land connections to Russia in Permian time.

The Lycopods afford the most interesting evidence of this land connection. Those discovered are identical with northern flora, yet they have been found associated with *Glossopteris* in South Africa, South America, and are entirely absent from India and Austarlia. Mr. Newell Arber says*: the occurrence there

"is probably best explained by the assumption that land connection existed in these [the two former] regions between the northern and southern continents."

I shall only refer to one more group—the Cordaitales—interesting to us because to it belongs the petrified wood so frequently seen among the forest sandstones. Trunks of trees as long as nine feet are not rare, and fragments are common on all coal-fields. So far as can be gathered, they may be referred to Dadoxylon, the stem of Cordaites, common also in Australia.

* *Op. cit.*, p. xxviii.

Specimens of fossils found in the Karroo beds in Northern and Southern Rhodesia are *Schizoneura gondwanensis*, *Glossopteris browniana*, *G. ampla*, *Vertebraria* (the rhizome of *Glossopteris*), *Gangamopteris sp.* and *Næggerathiopsis sp.* A calamite-looking stem was obtained from the Umsingwani coal-field (Tuli district), while there is in the museum a well-defined specimen of *Sigillaria* from the Sengwe. The occurrence of the two latter specimens of the northern flora in Rhodesia is peculiarly interesting, for Calamites, Cycadofilices and ferns of that type have also been found at Tete on the Zambesi in association with *Glossopteris*, and the Luano coal-field of North-Western Rhodesia has yielded *Schizoneura*, also a migrant to Europe, and Sphenophyllales, a visitor from the north. The land connection with the northern continent may thus have been nearer to Rhodesia than elsewhere—an inference strengthened by the existence of terrains of Karroo rocks on the middle Kafue and in Katanga, and by the opinion of Mr. F. E. Studt that sandstones of the Kundelunga series, comparable with our Karroo system, form the Congo basin. Search for fossils is a matter which should be taken in hand with zest, for they will materially aid to an understanding of the geography of the period, and show where and to what extent the overlap of northern and southern floras existed.

From the dense vegetation among which the *Glossopteris* flora grew was formed the vast deposits of coal occurring in Rhodesia. Of the formation of the coal beds there is much that suggests a different genesis to that of the deposits of the Northern Hemisphere. And they now form supplies of fuel under several thousands of square miles of the area of Rhodesia, placed in regions easily accessible by railway—supplies that are destined to play an important part in the future economic development of the country. It will thus be realised how much the flora of this age deserve a close investigation by our paleobotanists.

Distribution of Karroo Fauna.

The fauna of the Permo-Carboniferous is of equal interest to the flora.

The Karroo period, commencing at the close of the Palæozoic Age and running far into the Mesozoic, presents other interesting problems in its animal life. It saw the waning of the age of the invertebrates, and watched the dawn and waxing of a new creation—the age of reptiles and of fishes, mammals and birds.

The lakes, swamps and fern brakes of the newly growing continent seem to have been especially favourable for the development of these animals. Species and genera in great number existed, which included the forebears of crocodiles and lizards, and perhaps the first mammal-like animals. The earliest reptile, *mesosaurus*, lived here.

It is among the Karroo beds that the bones of these individuals are found in great numbers, on which Owen and

Huxley published their classic researches, and which have later been studied so closely by Professor R. Broom. Some sixty-four species of reptilia have been listed by Dr. Rogers.

All these genera swarmed the plains and jungles of Gondwanaland, and one South African reached India; other groups developed new forms in transit—so that there is little difference between the Indian and South African faunas. Some passed along the isthmus to the north, for forms typically Karroo have been found in Permian strata in Russia. *Mesosaurus* has been found in Brazil.

Karroo reptiles are, however, absent from Australia, and this may be due to break in the land connections to the east, passable to plants but not to animals. Yet they visited Rhodesia, for limestones on the Sengwe coal-field have yielded fragments of their bones. Near Broken Hill very fragmentary remains have been found in the later beds of the Luana coal-field, and Professor Broom has kindly examined them for me. He says that the deposit in which they are buried is not older than Permian or younger than Upper Triassic. There are small pointed teeth that may be those of either therocephalians, cynodonts or carnivorous dinosaurs, the little evidence there is being in favour of the deposit being either Upper Triassic (Burghersdorp beds), Molteno or Stormberg.

Other evidences of fresh-water conditions of the Rhodesian Karroo strata are the occurrence of the ganoid fishes (*Acrolepis*) and their scales, the little ostracoid crustacean *Estheria*, and the small bivalve mollusc *palæomutela*—all referable to the Permo-Carboniferous Age, and being represented in similar beds in Russia. The evidence of the geographical link with the northern Permian continent is thus complete, for any salt-water break would have been impossible to negotiate by the fresh-water denizens.

Probable Extent of an Ancient Continent.

The geographical extent of Gondwanaland is thus attested by fauna, flora, and general continental conditions, and though the various provinces are now separated by stretches of the deep, the vegetable and animal prototypes developed therein had a remarkable influence on the descent of the species of the present time, which possess a striking affinity in South America, Australia and South Africa, of which birds of the ostrich type are specially of notice. Diprotodont marsupials are represented in South America as well as occurring as abundant fossil remains in Australia, their dying out and disappearance from South Africa suggesting an early break of the land bridge. Fossil remains in Patagonia and Tasmania represent similar types, the absence of which from India and South Africa suggest that their distribution was by way of an even greater continental region to the south.

The exploration of the Antarctic continent is thus of deep interest to the South African geologist and geographer, and may be again referred to in view of the problems confronting us.

In this great land, opposite Cape Horn, Graham Land stretches in a point to the north, and there is only a break of some 600 or 700 miles of sea-water between. It is remarkable that a high range, called the Antarctic Andes, a continuation of the Andean chain of South America, runs right across the continent from Graham Land.

Of the little known of its geology we can see some similarity in tectonic relationship with the areas we have lately been discussing. Water-formed deposits associated with coal-bearing strata, laid down before the oncoming of its Ice Age, have been noticed, while volcanic activity attended the disruption from the lands to the north.

Knowing of great oscillations of the surface that are fully borne out by the geographical evidence of other periods and continents, it is not incompatible with present information to believe that this great land mass was at one time connected to America, Australia and Africa. It was inhabitable to the early types of the flora and fauna of Gondwanaland, and it is probable that they originated there, to be subsequently driven north by climatic change, such as has already given up Antarctica to frost and snow. Development from the early types would then follow in each continent, and survivors would again be pushed northwards through Africa to India, and through both to Europe and Asia. The former connection was probably along the east coast of Africa along the belt of less deep water, past the Maldive Islands and Seychelles. Madagascar was included, and although the submergence of continental portions of the greater mass took place before the Cretaceous period, this island was only cut off from Africa in the Tertiary period.

It will thus be understood how much we have yet to learn from the geologist of the South Polar expeditions of the rise and fall of this great land mass and its connection with Gondwanaland. It has been thought that the present zonal distribution of climates of the world has always existed. Did glacial conditions prevail there also in later Carboniferous times such as levelled down the mountains and filled the depressions of the Karroo and Gondwanaland? What were its ancient flora and fauna, and under what conditions of temperature and climate did they exist? What were its climatic changes, or periods of heat or cold, before the final onset of ice and snow that overwhelmed all except the minutest forms of life?

These are some of the problems of the rocks that yet await solution, and on which light may be shed by the worker in the Permo-Carboniferous rocks of the Southern Hemisphere.

Effect on Rhodesian Physiography.

Before closing I have something to say about the forces that are moulding the landscape of Rhodesia. It is fairly certain that much of these plateaux were covered by some one or other members of the Karroo sequence, of which the forest sandstone at Tabas Induna, the Somabula deposits and the Charter Amygdaloids are vestiges, also at present undergoing erosion. It cannot have been long, geologically, since this protective capping was removed along the margins of these deposits, and thus a pre-Karroo landscape has been, and is being, revealed, and is now open to the sunshine after ages of burial.

We can thus gather some idea of the physiography of this old land surface, and are struck by the remarkable evenness and maturity to which it had been brought in pre-Karroo times.

This uniformity is evident in many places—between Tabas Induna and Hillside, for example. During your visit to the Bushman's paintings you will be near an outlier of forest sandstone that, in the form of loose sand, chips of agate and chalcedony, covers the southern side of the Hillside kopjes. From this position looking north can be seen Tabas Induna, which is the receding edge of the Karroo covering, while in between is the lately exposed pre-Karroo landscape.

In North-Western Rhodesia the open plain stretches mile after mile, the horizon is as of the ocean, and the few hills, of not more that 300 feet in height, emphasise this contrast all the more.

The influence of the Karroo covering in shaping the features of Rhodesia is supreme. As the mantle was gnawed back by the Sabi and Limpopo river systems, erosion into the archæan floor was commenced. On the north side of the plateau crest the Zambesi basin still contains a great depth of clastic rocks, the porosity of which tends to pass the water down through the beds rather than over the surface.

During the middle Karroo and at its close, movements took place by which the Zambesi and Limpopo basins arrived at a level lower than the plateau ridge. The gentle nature of the resultant anticline may be judged by the fact that there is but a fall of fifteen feet per mile between Bulawayo and the Limpopo.

Dotted over the country are eminences and masses of rocks that are slow of decay, and it is notable that nowhere do they rise remarkably above each other. One might, as it were, place a straight-edge along their tops and on the summit of the plateau, and find that, with the allowance for the anticline above stated, they would all approach a general level. I therefore look upon these hills and mountains as bench-marks that indicate the level of the old pre-Karroo land-surface—the flat areas between them having been removed by erosion subsequent to the removal of the Karroo covering. All sculpture of the plateau has taken place since that event, and thus we find that regions that were earliest bared would now present a deeper incised appearance (such as the Mazoe and Sabi rivers) than those near the margins of the sandstone covering, as at Bulawayo and Gwelo.

As examples of my point we may take the Matopos. They are of the same general altitude as the plateau summit near Bulawayo, yet in between is the Malemu, which has eroded a valley in the contact zone of granite and schist, and cleaves the Matopos in its passage to the south. Yet to do this it must at one time have run over the top of a flat region connecting the high ground that lies to the north of the Dam Hotel and the Matopos —otherwise along the revealed pre-Karroo plains.

Other illustrations occur in great numbers. The Molungwane Mountains beyond Essexvale are of an altitude corresponding with the Matopos and Crombie's Ridge, with the Essexvale granite basin in between. The rapid and recent reduction of this circular basin is shown by the rapid fall of Fern Creek—almost a "hanging valley." The banded ironstone ranges of Belingwe, Tabas Inyoga, Victoria, Ghoka, Insiza, Iron Mask at Mazoe, Simoona, Belingwe, and elsewhere, and the granite of Hillside, Matopos, Tabas, Inyoni, Shangani, and Victoria suggest the same general principle.

The exceptions are those mountains of elevation that lie along the axis of the spinal movements of the continent, such as near Melsetter, Umtali and Inyanga and Fort Hill in North-Western Rhodesia.

The existence of the peneplane is supported by the courses of many of the rivers. The Umniati passes in its middle course over ground that still retains patches of Karroo rock; beyond, it cuts through ridges of quartzite; and finally, before its confluence with the Zambesi, cuts through a high range—a corner of the Urungwe plateau—of gneiss and granite. Yet by a course to the west the Sanyati (as it is then called) could have passed round the mountains in softer Karroo sediments. Here is evidence that its course was decided at a time that the Karroo deposits situate in the region of its middle section were at a level with the archæan ranges of its last section, the covering on the latter being earliest removed, and thus, when the river cut down into the underlying gneiss, it gradually drew off and eroded, and is eroding, the Karroo covering of its centre reaches.

Cases such as this are paralleled by the Gwai, Lubu, and Sengwe and the Limpopo. Somewhat different, but showing how they were directed in their courses over a higher surface, are the Hunyani, which passes through a poort in the range of hills next the railway, the Queque poort, Sebakwe poort, the Mazoe through the Iron Mask range, the Umfuli, the Kafue through the Niga Nega hills and others, the Zambesi itself drawn through the Kariba, Kebrabasa and Lupata gorges. The Lusenfwa is another case from North-Western Rhodesia.

If, then, the pre-Karroo landscape as now revealed was a plain of denudation of remarkable evenness, and if the end of the Karroo age saw another levelling up of all the depressions caused by the partial tilting of the strata of the plateau, we have other problems to face. Was the first the result of glaciation in Rhodesia, as in the Cape Colony, by which the pre-Karroo highlands, where our plateaux now are, were ground down and their debris carried to fill the depressions of the south? And in the last phase were desert conditions so persistent that they too exercised a levelling influence, and as effectively brought the great final Karroo landscape to another plain of remarkable uniformity?

SECTION C.—BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE, FORESTRY, PHYSIOLOGY, HYGIENE AND SANITARY SCIENCE.

PRESIDENT OF THE SECTION: F. EYLES, F.L.S., M.L.C.

WEDNESDAY, JULY 5.

The President delivered the following address:—

I cannot allow this occasion to pass without reference to the sad loss which the botanical world has sustained by the recent death of Dr. Harry Bolus, F.L.S. For a period extending over more than forty years his study has been, as it were, the head centre and clearing-house for workers in South African botany. His library of unrivalled completeness and beauty, and his herbarium of something like 30,000 sheets, have been at the service of, and have been used by, the most famous visiting botanists from all over the world. His unique knowledge of South African flora has always been placed at the disposal of young workers in the field, who have also received encouragement from him in other ways. His work as a botanist needs no words from me, and his labours as a systematist, specially in orchids and *Ericaceæ* alone, would be sufficient to ensure a lasting monument to his memory. I am sure you will join with me in deploring the loss to Science caused by his death.

Most men in civilized countries are under the necessity to labour continuously in order to sustain existence. The natural result is that knowledge, so far as it can be practically applied to the acceleration of industrial processes, is highly valued and highly paid. On the other hand it usually happens that the pursuit of pure knowledge for its own sake is given a secondary place, or is even treated with a measure of mild contempt. There is nothing strange about this, for it is to be expected that the daily struggle to secure the common necessities of life should tend to obscure the true but not obvious source whence have originated every one of the comforts and conveniences of modern life. The very substance of civilization as we know it will be found, upon examination, to be derived from the "divine curiosity" of the elect few who in each generation have assiduously fed the flame of knowledge, often without reward, always faithfully handing on the luminous torch as a sacred charge to their successors. Every new application of Science to the large uses of humanity momentarily draws attention to the patient, silent, ceaseless work of the lovers of knowledge for its own sake.

The discovery of the mysterious properties of radium, with its revolutionary influence upon the theories as to the nature of matter and the whole philosophy of the universe, would have attracted little general notice but for the hope that radium might be applied to the cure of certain previously incurable complaints. The discovery of the nature of malaria and other insect-borne diseases, with its wide and growing significance relative to the prevention and cure of numerous ills to which men and animals are subject, for the time compelled acknowledgment of the value of research in the field of pure Science.

But results quickly obscure causes. The fruits of hidden and little appreciated research appropriated by the practical man, soon appear as ameliorations and improvements of the conditions of our existence, and become commonplaces of daily life. The author of the new theory, or the discoverer of the new principle or fact, is forgotten. Indeed, the rapidity with which fresh knowledge is to-day assimilated and utilized is both remarkable and encouraging, and full of promise to the advance of the human race. It may seem a matter of secondary importance that every new stone added to the structure of civilization is brought to the building by the so-called theorist, or, at least, is quarried from a mine pointed out by him. He may care little for the building himself, and his share may be overlooked, but the fact remains that the supply of material depends upon the continuance of his work. The persistence, the insight, and the imagination of Darwin did not perish with him, nor do they live only in his eternal fame as a man of genius. They survive to-day in the operations of the stock-breeder when, as a matter of course, he applies Darwinian principles to the improvement of his herds; while their latest and not least significant development is seen in the birth of the new science of Eugenics.

Things which but a few years ago would have been incredible, and, if considered at all, regarded as impossibilities, are now accepted as accomplished facts and put to common uses. Mankind, which benefits by discovery and invention, may forget that each step in advance is initiated by, or made possible by, the labour of pure scientists, but it is proper to stimulate the devotees of science by reminding them of this truth, and we must not neglect to instruct our statesmen so that they may realize that no nation can keep in the van of progress unless research be regularly and adequately endowed. Audible conversation at a distance and the transmission of pictures by wire, marvellous as each seemed in its turn, are now eclipsed in wonder and utility by wireless telegraphy. The first sun-pictures were crude, evanescent and artistically disappointing, and gave little indication of the perfection to which photography would attain. But what shall we say of the more recent success in recording and reproducing of life in movement, an art that lends itself not only to amusement, but has also become the handmaiden of science in the study of animals in motion and the flight of birds?

Twenty years ago who could have foretold that we should live to see men as birds flying, not in cumbrous floating airships, but using machines heavier than air, controlled by wings imitated from the creatures of that element, and propelled by engines that are a triumph of modern applied science.

Truly no limit can be set to human accomplishments, and one must be very chary in using that foolish word "impossible." Well may we be lost in astonishment at man's attainments, while if, with prophetic imagination, we look into the future, we almost hold our breath as we watch the rapidly accelerating rate of progress, and wonder where we shall be by the end of this century.

At the same time, the splendour and the promise of these things, and the exhilarating sense of upward motion, will never conceal from the thoughtful man the certain fact that the secret spring of progress is always to be found in the study and the workshop of the unadvertised searcher after truth. Not only have the great advances of the past and the astounding attainments of the present alike had their origin in the same humble spot; all hope for the future also must be sought in the same place. If it could be imagined that the select band of truth-seekers now with us was the last, and that no successors could be found to carry on their sacred, self-appointed task, then mankind would come to a standstill, or nearly so, for all chance of new discoveries and inventions would then depend entirely on empiric work, and advance in civilization would be by intermittent jerks at irregular intervals.

I make this point to emphasise the dependence of practice upon theory, because it cannot too often be brought home to nations and to governments, in order that continual and sufficient encouragement may be given to research work of all kinds. The necessity for such encouragement exists everywhere, but it is specially apt to be forgotten or overlooked in young countries like Rhodesia. In reality the circumstances attending the opening up of new territories for the occupation of civilized man demand attention in this respect more urgently than is the case elsewhere, for then we have to encounter fresh and untried conditions as to climate, soil, inhabitants, diseases, animals, minerals, products of the land and general mode of living. Therefore, as soon as peace has been secured, government established, and communications opened up, one of the next and most pressing duties of the Government must always be to encourage and employ, so far as its means permit, a number of highly qualified men in various branches of Science, who should be freed from administrative responsibilities, and allowed to devote their whole time and energies to the study and elucidation of the problems peculiar to the locality.

The Rhodesian Government has done remarkably well in this matter, and has brought together a fine body of experts in the sciences of zoology, botany, bacteriology, and mineralogy. The trouble is that in a country of small population with limited revenues it is necessary that nearly all of these men shall devote the major part of their time to work of organization and administration. If it could possibly be arranged, it would be an immense advantage for each department, in addition to the officers engaged in actual control, to have attached to it at least one man whose sole duty and interest would be in the prosecution of research work. Taking the several branches of our particular section in the Government Departments of this and other countries, it will generally be found that all the staff is fully occupied on the economic side of their special study, whether it be bacteriology, botany, entomology, mineralogy, or forestry. It may be said that research is not the function of Government, and should be left to private enterprise or to institutions specially endowed for that work. This devolution of function may, and does, operate with some success in older countries, but in young countries there are seldom to be found any individuals of leisure qualified for and inclined to carry on research work. It also rarely happens that a country in its early stages of development possesses special institutions adapted for this purpose. And yet, as I have said, in young countries the need for research and investigation is much more urgent than elsewhere, and therefore it follows, if my argument is sound, that the endowment of research, on however modest a scale, must in these circumstances devolve upon the Government.

Section D.—ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.

President of the Section.—G. Duthie, M.A., F.R.S.E.

THURSDAY, JULY 6.

Not printed

LIST OF PAPERS READ AT THE SECTIONAL MEETINGS.

SECTION A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND IRRIGATION.

WEDNESDAY, JULY 5.

1. Address by Rev. E. GOETZ, S.J., M.A., F.R.A.S., President of the Section.
2. Some Observations on Atmospheric Electricity taken in South Africa. By Prof. W. A. D. RUDGE, M.A.
3. Electric Clocks. By Prof. H. BOHLE, M.I.E.E., M.V.D.E.
4. South African Climatic Conditions in Relation to Aviation. By R. T. A. INNES, F.R.A.S., F.R.S.E.

SECTION B.—CHEMISTRY, GEOLOGY, MINERALOGY, AND GEOGRAPHY.

WEDNESDAY, JULY 5.

1. Selective Absorption of Substances by the Earth's Crust. By Prof. E. H. L. SCHWARZ, A.R.C.S., F.G.S.
2. Notes on Investigations made on some South African Tobaccos. By M. LUNDIE.
3. Chemistry and Crystallography: A New Suggestion. By J. MOIR, M.A., D.Sc., F.C.S.
4. Twenty-five Years of Chemical Investigation in the Cape Colony. By C. F. JURITZ, M.A., D.Sc., F.I.C.
5. A Mineral Survey of the Zinc and Lead Deposits of Broken Hill, North-Western Rhodesia. By A. E. V. ZEALLEY, A.R.C.S., F.G.S.
6. The Occurrence of Scorodite in Rhodesia. By A. E. V. ZEALLEY, A.R.C.S., F.G.S.
7. The Sugar Content of Maize Stalks. By G. N. BLACKSHAW, B.Sc., F.C.S.
8. The Sedimentary Rocks of the Rhodesian Plateau. By F. P. MENNELL, F.G.S.
9. A Relation between the Geology and Metallurgy of Gold. By F. T. MUMFORD, A.I.M.M.
10. The Origin of the Rand Bankets. By Prof. E. H. L. SCHWARZ, A.R.C.S., F.G.S.
11. The Purification of Water. By Prof. H. BOHLE, M.I.E.E., M.V.D.E.
12. Theories of Atmospheric Variation. By D. TRAILL, M.A., M.B., Ch.M., B.Sc.

THURSDAY, JULY 6.

13. Address by A. J. C. MOLYNEUX, F.G.S., F.R.G.S., President of the Section.

SECTION C.—BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE, FORESTRY, PHYSIOLOGY, HYGIENE, AND SANITARY SCIENCE.

WEDNESDAY, JULY 5.

1. Address by F. EYLES, F.L.S., M.L.C., President of the Section.
2. The Latency of African Coast Fever. By E. M. JARVIS, F.R.C.V.S.
3. Notes on the Trypanosomiases of Rhodesia. By L. E. W. BEVAN, M.R.C.V.S.
4. Notes on Experimental Tree Planting in Southern Rhodesia. By W. E. DOWSETT.
5. Bacteriology of Milk. By J. C. JESSER-COOPE.
6. Rhodesian Tobacco. By C. S. JOBLING.
7. Modern Theories of Heredity. By W. T. SAXTON, M.A., F.L.S.
8. The Reproductive Organs of a Few Nudibrachs. By Dr. T. F. DREYER, B.A.

THURSDAY, JULY 6.

9. A Preliminary List of Rhodesian Plants. By F. EYLES, F.L.S., M.L.C.
10. Additional Notes on Evolution. By D. TRAILL, M.A., M.B., Ch.M., B.Sc.

SECTION D.—ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY, AND STATISTICS.

WEDNESDAY, JULY 5.

1. Address by G. DUTHIE, M.A., F.R.S.E., President of the Section.
2. The Present Position of the Discussion of the Origin of the Zimbabwe Culture. By R. N. HALL, F.R.G.S.
3. The Masarwas and their Language. By Rev. S. S. DORNAN, M.A., F.G.S.
4. Agricultural Education. By R. W. THORNTON.

THURSDAY, JULY 6.

5. The Position of Classics in Modern Education. By Prof. R. F. A. HOERNLE, M.A., B.Sc.
6. A Faust Problem. By Prof. W. S. LOGEMAN, B.A., L.H.C.
7. True Representation by the Transferable Vote, and what it would do for Southern Rhodesia. By J. BROWN, M.D., C.M., F.R.C.S., L.R.C.S.E.
8. Truth among the Pragmatists. By Rev. S. R. WELCH, B.A., D.D., Ph.D.
9. Notes on the East Coast Bantu of Eighty Years ago. By W. H. TOOKE.
10. The Universal Races Congress. By Mrs. J. F. SOLLY.
11. Some Notes on the Beginning of Rhodesian History. By R. N. HALL, F.R.G.S.
12. A Basuto and Bengali Folk Tale. By Rev. S. S. DORNAN, M.A., F.G.S.

THE ORIGIN OF THE RAND BANKETS.

By Professor Ernest H. L. Schwarz, A.R.C.S., F.G.S.

The origin of the gold-bearing conglomerates of the Witwatersrand is still a matter of controversy. The question is being attacked from the petrographical side and from the stratigraphical side, but so far no attempt has been made to read the riddle from a comparison with occurrences similar in nature in other parts of South Africa. It is one of the most marked features in South African geology that, throughout the period covered by the sedimentary beds, conditions of deposition have recurred several times, producing similar deposits; and as the story of the younger formations is tolerably plain and that of the older obscured by metamorphism and from other causes, such as the formations being only partially exposed by denudation, it may be of use to see whether we cannot apply what we know about the conditions which produced the younger beds to account for the older, and whether observations confirm the analogy or otherwise.

There are three groups of facts connected with the Neo-Afric beds in Cape Colony which I think have a distinct bearing on the question of the Pal-Afric beds of the Transvaal, especially the Rand Banket. It is the purpose of this paper to describe them in detail and then to apply the principles to the conditions which led to the laying down of the beds now existing as the quartzites and conglomerates on the Rand. The three groups of facts are:—

The three-fold Cape System, consisting of two shore deposits (sandstones) with an intervening deep water deposit.

The Uitenhage System, consisting of a great gravel series at the base; then a fresh-water and sub-aerial series, consisting of marls and blown sands; and a marine deposit on top.

The System of Folds on the south coast, which has caused the Table Mountain sandstone to be folded on itself several times.

The Cape System.

The Cape System is made up of the three conformable series: Table Mountain sandstone at base, non-fossiliferous; the Bokkeveld Series above, consisting of shale and a few sandstone bands, and containing lower Devonian fossils; and the Witteberg Series on top, consisting of fine-grained ferruginous quartzites with subordinate shale bands, containing Lepidodendra, referred to the lower Carboniferous. As far as we can make out, the land-surface which provided the sediments of the Table Mountain sandstone lay to the north. There are conglomerates at Pakhuis Pass and on the west coast, but otherwise the rock consists of coarse-grained sands markedly false-bedded and occasionally showing bands of white quartz-pebbles, sometimes even odd boulders of considerable size. Towards the top there is a wide shale-band, which in the north-west contains glaciated boulders. The whole aspect of the series, which at its fullest is 5,000 feet thick, is that of a deposit laid down close in-shore, with turbulent and shifting currents. It has been proposed, to account for the false-bedding, that it is a sub-aerial deposit, as Tennison Woods proposed for the Australian Hawkesbury sandstones, which, in many respects, are similar to the Table Mountain sandstone, but the shale-band within the Table Mountain Series and the perfectly conformable junction with the Bokkeveld marine beds above negative this conclusion; while the sand-grains are of the ordinary water-worn variety, and are not rounded by wind action. There was a southern land-surface which, however, only comes into actual observation in the succeeding Karroo period; it is usually regarded as a long narrow peninsula like the Malay Peninsula, and, as Madagascar is a remnant of this land-surface, it is conveniently referred to as " the old Madagascar ridge." Whether the explanation of the false-bedding in the Table Mountain sandstone can be helped by this ridge is a matter of opinion; the turbulence of the water flowing backwards and forwards through a comparatively narrow strait would produce the intense false-bedding. Until, however, the old Madagascar ridge rose still further and formed the southern boundary of the great Karroo lake we have no definite knowledge of its existence, hence any explanation that implies its presence in previous times must be merely speculative.

The northern shore of the Table Mountain sea then retreated northwards, and over the shore deposits of that period were laid down the deep-water deposits of the lower Devonian. We are certain that these sediments were derived from a land-surface to the north, because in the width of the exposure on the south coast the beds on the north are interstratified with three great bands of white quartzite, showing that the sea-floor was oscillating, and that every now and again it came within the reach of littoral deposits; on the south, near the present coast, however, these sandstone bands are only feebly developed, or are entirely absent, indicating deeper water conditions. Where the now submerged coastal plains existed in the period of deposition of the Table Mountain sandstone, the littoral deposits of the Bokkeveld beds were laid down; these consisted probably of sediments differing but little from those of the Table Mountain sandstone. In the following period, the Witteberg, the shore-line again crept southwards till it reached—or probably surpassed by a little—the line it occupied in Table Mountain times; the loose, recently formed Bookeveld littoral deposits were exposed to the action of denudation, and became washed down by the rivers and laid upon the deep-water sediments of the Bokkeveld. Hence the sand-grains would suffer a double attrition, first after their original disintegration from the rocks, granite, etc., of the old continent, and secondly after their being compacted into the littoral deposits of the Bokkeveld; hence the grains would be on the whole finer than in the Table Mountain sandstone. The higher iron content of the Witteberg rocks as contrasted with the Table Mountain sandstone is, I think, largely a secondary effect. The iron is frequently arranged in nodules and concretions and along special layers in the rocks; occasionally these nodules are so rich that the earthy varieties are worked for red and yellow ochre: these facts show clearly that the iron in solution was actively circulating in the rock, and it is obvious that since a finer-grained sandstone will have a larger pore-space than a coarser-grained one, so more iron would circulate in the finer than in the coarser sandstone—in other words, the Witteberg would be more ferruginous than the Table Mountain sandstone. However the conditions of deposition may have rendered the Witteberg beds originally more ferruginous, owing to the fixing of iron in ironstone gravels on the surface of plains, such as we see going on all over South Africa at the present day. The loose littoral deposits of the Bokkeveld would rise from the sea as a more or less featureless plain on which drainage was imperfect. The roots of the Lepidodendra and other plants which we find as fossils in the Witteberg rocks would yield organic acids which would dissolve the iron from the rocks, and the organisms in the soil would precipitate this iron as moor-bed-stone beneath; some such concentration of the iron on the land-surface is quite probable, and on the final cutting away of the plateau these beds of hard ironstone gravel would help to enrich the sediments forming off-shore.

In the Transvaal System there is a similar three-fold system consisting of the Black Reef below, made up of quartzites and conglomerates; then a dolomite series; and the Pretoria series on top, consisting of quartzites and shales, often highly ferruginous. The same sequence in the nature of the deposits signifies similar methods of deposition, the dolomite taking the place of the deep-water Bokkeveld shales; but the parallelism otherwise is very striking: the quartzite bands in the Bokkeveld series nearer the original shore are frequently copied in the dolomite by bands of ferruginous quartzite appearing towards the top of the series. The Transvaal System is represented on the east in the escarpment facing the low country, and then right through the breadth of South Africa to German Namaqualand; much of this country is untraversed, so that it is impossible yet to use the teaching of the Neo-Afric beds for the reconstruction of the continent from which these Pal-Afric beds were derived. It is significant that they form a broad band, longer, it is true, than the Cape formation is known to extend, but of a similar nature, and that further north, although there are Waterberg and Karroo beds, as at Lake Tanganyika, the area shows continental conditions during the deposition of the Transvaal Formation.

The Uitenhage System.

The basement series of this system consists of gravels known as the Enon Conglomerate. At the base there are some 1,500 feet of red conglomerate, followed by some 500 feet of white conglomerate. The pebbles are of white quartzite, averaging in the Red Enon about the size of a duck's egg, but occasionally being as large as one's head; the pebbles of the white Enon are sometimes the same as those of the red, but occasionally are, over wide areas, very much larger. The matrix is gypsiferous clay, in the red variety stained with iron. This enormous deposit of gravel is the direct result of the folding of the coastal ranges of mountains. So far it has only been found on the sea-ward side of them, but it is possible, as it is found in the valleys between the ranges, that it may have been formed on the landward side as well, but has subsequently been swept away by denudation. It is found from Uitenhage to Worcester, a distance of 550 miles, and though showing considerable variations, is in the main characterised by the same features. Usually the gravels are water sorted, with pebbles of equal size arranged in layers which may be separated by banks of sand; at other places, as at Knysna, the Conglomerate may consist of all sizes, mixed with a considerable amount of sandy matrix between, such as in the material formed by avalanches in the Alps. The conditions of deposition are as follows: The coastal ranges had been recently folded up; the rocks participating in the folds were the Cape formation, and at any rate the lower members of the Karroo beds, as these are found on the seaward side of the mountains; the more superficial rocks were structurally weak from the intense bending, and the mountains were high, possibly snow-capped, and plentifully supplied with water, hence great masses of *débris* were washed down the sides of the mountains. Beneath, there was a flat coastal shelf. The water of the torrents carrying great burdens on the slope, owing to the energy given to the water by the steep descent, was suddenly spread out on the flat at the foot, and the carrying capacity of the water was reduced very considerably; hence, although the water was sufficient to carry away the finer material from the *débris*, the larger boulders were left behind. The mountains presently became lower; water became more scarce, and over the surface of the gravels the rivers carried only sand and mud, frequently ending in lakes, drainage from which was through the conglomerate below. The surface of the gravel was little below sea-level. Hence were formed the lacustrine deposits, æolian sands and estuarine marls of the second member of the Uitenhage series, the Wood bed. The surface of the land sank still further, and over the whole were laid down the Marine beds, containing abundant ammonites and trigonias, which sufficiently date the deposit as Neocomian. On the rising of the land the whole of this loosely compacted series of rocks would have been swept away, as those forming the littoral deposits of the

Bokkeveld were, but fortunately a number of fault-pits were formed, which let down portions of these Cretaceous beds in basins surrounded with rims of harder, older rocks. Thus portions of the Uitenhage Series have been preserved. That the deposit was originally continuous we know from the fact that from fault-basin to fault-basin the rocks are, to all intents and purposes, identical.

The main interest in the Enon Conglomerate in South African geology is that we have a fluviatile deposit between 500 and 600 miles long and some 200 miles broad; there is no difficulty, then, in ascribing the Rand Banket to fluviatile origin, which at most covers an area of 180 miles long by 80 broad. In the case of the Rand we must suppose that the four granite bosses of Potchefstroom, Johannesburg, Parys and Heidelberg form the cones of mountains which towered above the plains in the pre-Witwatersrand days. The first two are more interesting to us, as the gravels washed down from these mountains are now highly auriferous, while the gravels round the sockets of the southern mountains have not yet been proved to contain payable gold. The rocks above the granite were what we now call the Swaziland schists, in those times probably little more metamorphosed than the beds of the Cape formation are now. If they contained ore-veins, the gravels near their bases would contain these ores as natural products of disintegration. Why gold is precipitated in gravels and not in finer sediments is a question not yet properly explained, but the fact remains that if the country rock contain but the most exiguous traces of gold, the rivers—large ones like the Irrawaddy and Rhine, or small ones like the Homtini at Knysna—carrying the gold do deposit it in the gravel patches. It might be advanced that the granite should show traces of these ore-veins which are supposed to have existed in the schists above them. This, however, is a question that has only to be answered for those who believe in Posepny's theory of the ascent of mineralising waters from below; on Sandberger's lateral secretion theory, the gold or other metals would find their way into the ore-veins by solution from the country rock and passage of the solutions into the open spaces and crevices where the water relieved from pressure deposited the ore and gangue. To the Ascensionists the reply is that the granite which shows no traces of gneissose structure would be, when it was intruded, in a liquid state—that is, in a condition in which pressure was communicated equally in all directions—and therefore the crystals developed without reference to any guiding directions; hence the passage of mineralising solutions would be accomplished through the mass of the rock, without being restricted to definite channels, and without leaving any traces behind. It is unfortunate for South Africa that the Enon gravels are mostly derived from the disintegration of comparatively young rocks, which have not been mineralised, so that the Enon gravels are barren in regard to their gold content; but more recent gravels have been formed from the same range of mountains, which, in the process of time, have been worn down so that the deeper lying beds have been exposed. These deeper rocks—the Table Mountain sandstone, for instance—do contain small reefs of gold in quartz veins and bankets, and the gravels derived from them, therefore, are auriferous, as on the Poverty Flats in Knysna.

THE SYSTEM OF FOLDS ON THE SOUTH COAST.

To confine the limits of this paper, we can restrict our attention to the folds which run almost due east and west along the western margin of the south coast of South Africa. The area of the earth's crust has sustained a thrust from the north, due to the intrustion of dolerite in the Central Karroo and accompanying disturbances, which has been brought up against a line of granite bosses, which have barred the way for the movement of the earth's crust seawards. The result of the thrust is best seen on the road from Mossel Bay to Oudtshoorn and Prince Albert: the Table Mountain sandstone has been folded like a sheet of paper into innumerable folds, closely pressed together (isoclinals) to the south and more open to the north, but most of the limbs inclining seawards. To the east of George, where the granite ends, the strike of the folds splays out seawards and the ranges run east-south-east. It has frequently been advanced that the granite bosses pressed in from the sea; but if a series of folds are compressed at the base, they must incline in the direction of the thrust, hence the thrust, to my mind, must have come from the north. The dolerite intrusions of the Central Karroo are contemporaneous with the folding, and are an adequate cause. In the Alps a further action has taken place: the thrust from the north, spending itself on the line of granite bosses in the north of Italy and adjoining countries to the east and west, has caused the beds caught in the nip to crumple up with the axes of the folds fan-fashion; in the South African coastal ranges the north side only of the Alpine structure is developed. There are beds of Banket in the Table Mountain sandstone, but they are only recorded from Knysna and Oudtshoorn in single occurrences; had the banket been more prominent, and had it been exhibited in, say, the section of mountains between Mossel Bay to Oudtshoorn called the Outeniqua Mountains, then the banket would have appeared at the surface some six or eight times, each bed apparently above the other and to all appearances conformably above the last. Such a false conformity has been called by Grabau a disconformity. Had, further, the banket been like the Enon Conglomerate, which, as it is followed from place to place, changes from a series of continuous gravels to a more or less alternating series of sands and gravels, each banket reef would appear to be different from the ones above and below, although we could, in the case of the Outeniqua Mountains, prove that the banket was continuous up and down the loops of the closely compressed synclines and anticlines.

These conditions, applied to the Transvaal, would indicate that the several groups of banket reefs are reduplications of one and the same series. The Main Reef series contain nominally some six separate reefs; then there are some 1,500 feet of quartzites; then the Bird and Livingstone groups of reefs, 400 feet thick; then another 1,500 feet of slates and quartzites; then the Kimberley group of reefs, containing over a hundred separate reefs and often 2,000 feet in thickness; then another 1,500 feet of quartzites, and finally the volcanic agglomerates. This is a rough general review of the grouping of the bankets, but every section gives a varying thickness to all the beds, both conglomerates and quartzites. The beds of conglomerate also vary in number along the strike; in fact, the conditions of the upper portion of the Enon Conglomerate as it is seen along the Olifants River in Oudtshoorn is closely paralleled. The three natural groups of the banket reefs may be taken to represent the lines of isoclinal anticlines of sandstones containing conglomerate beds near their basal margin; the lower Witwatersrand beds may be said to underlie disconformably the upper quartzites and conglomerates. The conglomerates are due to fluviatile or fluvio-marine action; the ordinary inshore sands derived from the weathering of the old mountain land were periodically raised to the level of the sea or above; the mountains, given a greater altitude, were wrapped in torrents which carried down the *débris* and spread it out as a layer of boulders over the sand; the progressive sinking of the earth's crust at this particular place was resumed, and the bankets were covered by sand. The gold weathered from the rocks of the old continent was carried down by the rivers and deposited in among the pebbles of the conglomerate. Only the conglomerates near the source of the supply received a notable quantity of gold; those further away received only a little; therefore the bankets of the first syncline only would contain appreciable quantities of gold, and are the only ones which have been found worth working. The gold was originally patchy placer gold, but owing to the circulation of water under great pressure, the banket became approximately equally enriched in gold all through.

I remarked at the beginning that conditions at the deposition of the South African beds were constantly being repeated throughout the rock series; for instance, in the banded ironstones of the Swaziland, Lower Witwatersrand, Pretoria and Witteberg Beds, one and the same specimen of rock often may do duty as an example from at least any of the first three systems. In the case of the Rand Banket we have another example. The quartzites and conglomerate are repeated in a supposedly younger series, the Black Reef, the lowest bed of the three-fold Transvaal System. Hence we are justified in asking: Are not the banket reefs of the Witwatersrand System the same as those of the Black Reef, and are not the Witwatersrand beds as a whole but the metamorphosed representatives of the Transvaal System?

In the Lower Witwatersrand beds the various strata are sufficiently well characterised to allow their recognition over considerable areas, and the series seems to be a normal succession of slates and sandstones; but the Upper Witwatersrand series, with its 10,000 feet of quartzites and conglomerates, presents difficulties of deposition which are harder to explain. The Table Mountain sandstone consists of 5,000 feet of fairly normal sandstones, cemented, it is true, with a certain amount of silica, and in the fresh state with a considerable amount of iron sulphide, which disappears on the surface owing to the coarse texture of the rock allowing free circulation of oxygenated water. This can be explained as deposit in a channel near inshore, but even here the conditions were unable to last the whole time, and there is a big bed of slates near the top. Ten thousand feet of inshore deposit—and this compacted and compressed so that it represented probably only half the original thickness of the series—is a very great thickness, and seems beyond what could happen under conditions of deposition such as we know them: this is the state of the case with regard to the Upper Witwatersrand beds. The sand is derived from the weathering of a continent, and must be laid down near the shore to account for the gravelly patches, now banket; one has to assume that the deposit was always a shallow one, sometimes even being exposed above the water-level, so that the floor of the ocean in which the sand was being laid down would have to sink continually, the land being supposed to rise in compensation and to provide fresh material for disintegration. To assume that the Upper Witwatersrand beds is a single continuous series, we must also assume that the crust sank continuously 15,000 to 20,000 feet, and that the shore remained in the same place all the time.

It seems therefore that, although the deductions from field-survey must always carry more weight than theoretical speculations, nevertheless, there are certain facts about the stratigraphy of the Witwatersrand which leave one with curious false conclusions if tested from a causal point of view. We know so little about the conditions of the earth in remote ages that it is the custom to say that any reference to them is superfluous, and the only thing that matters is the correct plotting of the boundaries of the formations. We now know, however, so much about the earth, and the exploration in so many lands enables us to bring to the elucidation of any one part so many facts from similar countries elsewhere, that it seems to be time to discard the older methods, safer though they be, and try and raise the science of geology from a simple cataloguing of facts into its proper domain as a causal science.

NOTES ON EXPERIMENTAL TREE-PLANTING IN SOUTHERN RHODESIA.

By W. E. Dowsett.

The following brief remarks relate chiefly to the work carried out in the Rhodes Matoppo Park during the last seven years. This has been done in pursuance of the wishes of the late Cecil Rhodes, who was an ardent lover of trees, and who, with his great forethought, realised the serious problem which might some day confront the settlers in Rhodesia, especially the mining community, unless afforestation were undertaken in the immediate future. With this end in view, he had a clause inserted in his will to the following effect:—

"And in particular I direct my Trustees that a portion of my Sauerdale property, near Bulawayo, be *planted with every possible tree*, and be made and preserved and maintaiued as a Park for the people of Bulawayo."

The object of his emphasising the wish that every possible tree be planted was undoubtedly with the view of ascertaining by experience which trees would be found the most suitable for practical purposes in this territory.

In order to do this, a block of ground—1,800 acres in extent—was selected a few miles north of the World's View, so as to give those visitors to the View who took an interest in the subject an opportunity of seeing for themselves the results of the experiments being carried out. The work completed so far has been entirely of an experimental nature—only a few trees of each variety have been planted—as the area available will not admit of large plantations being laid out, and the idea has been to experiment with as many species and varieties as possible.

Block Arboretum.—The first work undertaken was the laying out of a block arboretum, each block containing twenty-five trees of the same variety: up to the present this consists of 114 blocks, made up as follows: Eucalypts, 46; Pines, 12; Cupressus, 12; Junipers, 4; Callitris, 5; various other species, 35.

Single Specimen Arboretum.—In addition to the block arboretum, there is a single specimen arboretum containing about 250 species and varieties, and at present there are some 75 new varieties in the nursery.

It will be realised that in experimental forestry there are so many points to be considered, and difficulties to be overcome, that it must necessarily be a matter of time before one can speak with any degree of certainty as to the success or failure of any particular tree. Up to the present there are several which give good promise of ultimate success.

Cupressus.—The various varieties of Cupressi have almost without exception done well, and they have made good growth. Of the most successful I must mention *C. elegans* and *C. Gaudulepensis. C. Lawsoniana, C. goveniana, C. arizonica* and *C. lusi-*

tanica have also done very well, making good growth and not suffering from the frost. A large number of *C. sempervirens* have suffered from what I take to be sun-scorch; this occurs at the extreme top of the tree, and has been found to affect them on dfferent soils.

Pinus.—Of the Pine family, *P. longifolia,* or Cheer Pine, has done better than the others, and as it is of great economic value, containing tar and turpentine and bark for tanning, it should be grown extensively. *P. halepensis* (Allepo Pine), *P. pinaster* (Cluster Pine), *P. insignis,* and *P. Canariensis* (Canary-Island Pine) have also done splendidly in the Matoppos.

Callitris.—Of the Callitris family *C. calcarata, C. robusta, C. rhomboides,* and *C. Whytei* seem to have done best: their growth has been remarkable, and there is little doubt as to their ultimate success; I have no record of the loss of a single tree of this species in the Matoppos, either by drought or frost. They are all of good quality timber, and, being ant-resistant, should be extensively grown. The wood is very valuable for furniture and building purposes.

Eucalypts.—Of the Eucalypts, the following are the most promising, their relative value being in the following order: *E. salinga, E. tereticornis, E. robusta, E. citriodora, E. polyanthemos, E. redunca, E. sideroxylon* and *E. rostrata*; most of the others have done fairly well, but *E. gomphocephala, E. salmonophloia, E. amygdalina, E. salubris* and *E. leucoxylon* have failed.

Miscellaneous Species.—Dealing with a few other species of the most successful growth, I might mention *Albizzia lebbek* (Siris acacia). This is a fine avenue tree, and produces a good deal of gum. The *Juniperus Bermudiana* (Pencil Cedar), *J. Virginiana* (Red Cedar), and *J. Mexicana* have done remarkably well, and should be extensively planted: practically no losses have occurred through termites, drought or frost. The *J. Bermudiana* is a faster grower than the *J. Virginiana* and *J. Mexicana*. All of these appear to thrive on the poorest of soils. *Juglans nigra* (Black Walnut), *Fraxinus Americana* (American Ash), *Grevillea robusta* (Silver or Silky Oak)—the latter a quick grower and good drought resister*—should be given a good trial throughout this territory. *Cedrela toona* (the Singapore Cedar), a very valuable cedar-like timber, much prized in India, has done well, and it would appear not to be affected by frost or drought. *Jacaranda mimosafolia,* a handsome tree which furnishes a beautiful and fragrant kind of Palisander wood (*vide* von Mueller), is a rapid grower, and although slightly affected by the frosts for the first two years, appears to be very hardy when older: a splendid tree for avenues.

From a general survey of the results of experiments carried out in the Matoppos, it is evident to my mind that afforestation

* The timber of this tree is much valued for furniture, and it has done as well as any other species, being such a valuable timber and apparently growing vigorously on poor soil.

in Rhodesia could be conducted with every prospect of success, and the question of the establishment of a Forest Department should have the earnest consideration of the British South Africa Company at an early date. At the same time, it would well repay farmers and others to set aside a portion of their land for this purpose, for the work could be undertaken at very little expense and without a great amount of supervision, while the result would be the provision, not only of necessary shelter belts for stock during winter, but also of timber of considerable economic value, as well as of firewood.

Climatic Conditions.—I should like to point out that the conditions here are entirely different from those prevailing in most parts of South Africa. At the Cape you have a rainfall ranging from thirty-five inches to seventy inches, commencing in May and ending about September, with occasional showers during the summer months; there is no frost, and the extreme summer heat is tempered with a moisture-laden wind. Here the rains may commence in November and go on until April, but we generally expect the rainy season to commence about Christmas and cease about March, with a total rainfall of about twenty-one inches. The frosts may commence any time after March; this year the first frost recorded on the grass in the Matoppos was on the 26th March, when one degree was recorded. As much as ten degrees were recorded on the 6th April: this was an exceptionally low temperature for the time of year. Last year the frosts commenced on 14th April, and continued practically without intermission until the middle of September, a period of twenty weeks. Frost was recorded on twenty-eight days in May, twenty-two days in June, twenty-six days in July, sixteen days in August, and four days in September; as much as twenty-one degrees of frost were recorded on the 9th and 25th July. From the above remarks the great difficulty may be realised that one has to contend with in raising seedlings during this period, March to September.

To turn to the dry season, very little rain falls between the middle of March and middle of November. No precipitation has been recorded in the Matoppos during the month of August for the whole time that records have been kept there, a period of eight years; so that it is absolutely necessary to have the ground thoroughly prepared ready for planting as soon as the first good rains occur, as the planting season is so short and the cold, dry period so long, and unless the trees are got out in the field early they will have a hard struggle to survive.

When the work was first undertaken in the Matoppos the "pit" system was adopted; this system was that which met with great success in certain parts of India, the pits, about four feet by four feet, being partly filled in with decayed leaves, etc., and soil, and trees planted in these survived in most cases where sometimes the indigenous trees were killed by exceptional droughts. Here, however, this method did not succeed, one of the chief reasons being that it was almost impossible to keep grass-fires from destroying the trees, as they were planted out at distances varying from twenty to sixty feet apart, and the ground not being ploughed, it was hardly possible to clear sufficient space around the trees to ensure their safety. This grass was about five feet in height, so the almost impossible task of fighting the fires can be well realised.

Of course this mode of planting does not refer to the plantation work, which was not undertaken for some three years after the initial planting. The method that has been employed in the Matoppos for the past four years is to get the fresh ground well ploughed at the end of the rainy season and left during the winter, until the first rains of the following season; then re-plough, harrow, and, if necessary, level; in the meantime the soil has become aerated and disintegrated. After the young trees are put out the ground is kept well cultivated by means of a horse-hoe or a single-section harrow; where the planting is sufficiently wide apart, this cultivation is continued throughout the winter, with the important result that the weeds are kept under during the rainy season, and the subsoil moisture is conserved during the winter.

I am strongly of the opinion that in cultivation lies the true secret of success in tree-growing in this territory, *i.e.*, Matabeleland (in Mashonaland there is a much heavier rainfall, especially in the northern parts), and unless it is kept up for the first year little or no progress will be made. In the Cape, hoeing is done occasionally to keep the weeds under, but here it is essential if the trees are to be kept alive. Mulching is resorted to sometimes, but it is not to be recommended where termites are in large numbers, as these are apt to attack the young trees so treated, being attracted by the mulch.

Size of Trees when planted out.—With regard to the age and size of the trees to be planted out here, I find that the Eucalypts should be of such a size that it will not be necessary to cut their roots in the nursery tins, as when this is done the plant at once makes a certain amount of dead wood, and the termites will be almost sure to attack it. The finest Eucalypts in the Matoppos have been planted out when they were about two and a half to three inches in height and about three months old. These trees have attained a height of sixty feet in six years, which may be considered very satisfactory progress. Pines, Junipers, Callitris and Cypress have mostly been two years old when put out.

In-situ Sowings.—This has been tried only with Black Wattle (*Acacia decurrens*) among the exotics, and has been quite a success. The seed was sown three seasons ago, and the trees are now on an average fifteen to twenty feet in height. The seed germinated in a very even and healthy state, and after the young seedlings were thinned out very few losses resulted. It is intended to try Pine sowings next season, but it is doubtful if they will be a success as the long, dry winter may prove too much for them. All the seed sown *in situ* has to be treated with poison to prevent them being destroyed by field-mice and other vermin.

Indigenous Trees.—This article would not be complete without reference being made to our native trees, and I therefore propose to make a few remarks thereon. I am firmly of the opinion that several of our indigenous trees are well worthy of cultivation under forest conditions; in the Wood Museum at the Matoppos there are forty-seven specimens of native timbers. These have not been treated in any way, and have been cut vertically, diagonally, and horizontally, in order to show the various grains. Most of these have now been cut from four to six years; out of this number twelve have been attacked by borers and eaten right through, and six have been attacked in the sap-wood only, whilst the remainder are intact and in excellent preservation. Experiments are about to be made to test their durability in the ground, and their resistance to ants and decay.

Of the more valuable species I might mention *Afzillia cuanzensis* (Rhodesian Mahogany). This is a valuable furniture wood, and should be extensively grown; a small plantation of these has been laid out. They are very slow growing for the first two seasons; there are a few trees five feet in height.

Bolusanthes-speciosus (Rhodesian Wisteria).—A good hard wood; is considered to be as durable as Sneezewood as a fencing post, and at present fetches the highest price up here for that purpose. The Rev. Mr. Helm, of Hope Fountain had, a couple of posts of this tree in the ground for twenty years as part of a belfry, and when he was removing the bell to another site he had them taken up, but found them in such splendid condition that he arranged for their removal to the new site, and there they have remained for the last thirteen years, making a total of thirty-three years in all, and they are apparently in as sound condition to-day as when first cut. There is a small plantation of these trees in the Matoppos, the present height being about four feet. They were sown about two seasons ago.

Faurea saligna (Transvaal Beukenhout; Terblantz of the Cape).—This is a fine straight evergreen tree, sixty feet in height; the timber is largely used for cabinet work, and is much prized.

Olea verrucosa (Wild Olive).—A small plantation of these trees is doing well, the plants being first raised in nursery beds. This tree attains a height of twenty to thirty feet, is very valuable for furniture, tools and wagon-work; it is, however, slow-growing.

Pterocarpus Angolensis (Kajatenhout).—This is a very handsome tree; wood fairly hard. The tree attains a height of forty to fifty feet; the timber is suitable for furniture, tool-handles, &c.

Pterocarpus sericeus (N'dhlandlovu).—A handsome tree forty to fifty feet in height; its timber useful for wagon-work, disselbooms, &c.

Terminalia sericea (Rhodesian Yellow Wood—Assegaihout).—This tree furnishes one of the most durable fencing posts, and for building purposes can hardly be surpassed, provided it is properly seasoned. A fine young plantation of this species is growing in the Matoppos, some of the trees being ten feet in height at four years old, and are fine, straight-growing trees.

Parinarium mabola.—A tall tree with a spreading crown; its timber is excellent for building purposes and fencing, and is said to be ant-proof.

Pteroxylon utile (Sneezewood).—This tree is found growing here and there throughout the country, but is not well grown. A small plantation in the Matoppos raised from seed obtained from Uitenhage has done well; it is on an average ten feet in height at seven years old, and is in a healthy and vigorous condition. The value of this wood can hardly be overestimated.

Sowings of Indigenous Seed.—Experiments made with sowings of indigenous seed have proved that it is almost impossible to raise the seedlings in the nursery and transplant to the plantations: in almost every case this has been a failure. Certain trees have been so treated, *viz.*, *Olea verrucosa* and *Pteroxylon utile*, but in the majority of cases *in-situ* sowings have had to be resorted to. For two seasons the nursery system was tried, but without success.

Destruction of Native Forests and Bush.—There is little doubt but that this territory was once covered with dense woodlands which have been more or less destroyed by the natives, either through cutting down to make way for their fields or gardens, or by means of grass fires, which have been started with the object of securing fresh pasturage for their stock (the idea being to burn off the old rank grass and allow the young grass to spring up). It is needless to say that they never attempt to control these fires in any way, allowing them to sweep onwards and do what damage they may. In this manner all the decaying matter on the ground, leaves, dry grass, etc., is destroyed before having time to produce humus; the trees in the forest are more or less damaged, and this damage renders them susceptible to the attacks of termites, and so the damage goes on. Seedlings are, of course, destroyed, and the only wonder is that there are any trees left in the country, for these fires are an annual source of danger to all plant life. If reproduction were undertaken systematically, and the better forests strictly conserved and protected, I see no reason why, in a few years, we should not only produce all the timber required for this territory, but also open up an export trade with the Southern Colonies of our better native timbers.

One of our chief points to be taken into consideration in the matter of laying out plantations on a large scale is that of the cost of land (and here, I think, we can compete with any other part of South Africa). Another important consideration is that branch or feeder lines are gradually being constructed throughout the country, enabling timber to be transported at a cheaper rate to the various towns and mines. In a country whose chief industry is mining, naturally the most profitable branch of forestry will be that which provides for the timber requirements of the industry. Here we can safely look for a return on the capital expended at the end of, say, ten years in the shape of stope-timbering, etc., and, of course, we must not forget that the thinnings and prunings will provide a considerable income for firewood long before this period is passed.

I trust that these few remarks may be of some use in showing that, although our territory has been greatly denuded of its natural woodlands, we may confidently look forward to the time, in the not distant future, when Rhodesia will derive a very considerable advantage from the practical results which should be the natural outcome of the experiments carried out at the founder's instance in the Matoppos.

EUCALYPTUS OIL IN ORE CONCENTRATION.—A recent regulation of the Health Board of Australia requires eucalyptus oils for therapeutic purposes to contain at least 50% of eucalyptol. This, it is said, excludes phellandrene oils, which give the best results as a reagent in ore concentration. A Broken Hill ore concentrate, containing 47% zinc, 10% lead, and 15 oz. of silver, is obtained with a consumption of 8 oz. of eucalyptus oil per ton of concentrate, and the demand for phellandrene eucalyptus oils has, in consequence, greatly increased.

GRANTS FOR RESEARCH.—A joint committee of the Royal Society of South Africa and the South African Association for the Advancement of Science was recently appointed for the purpose of considering the possibilities of establishing a fund for the furtherance of scientific investigaton in Southern Africa. This committee has reported favourably on the project, and has recommended to the respective Councils of the two Societies that the funds out of which such grants are to be paid should be administered by the President and Council of the Royal Society of South Africa, and that all payments should be subject to the sanction of a General Committee consisting of the President and Council of the Royal Society, four members nominated by the President and Council of the South African Association, two members nominated by His Excellency the Governor-General in Council, and one nominated by the University of the Cape of Good Hope, together with representatives of the various Societies in South Africa devoted to the interests of special branches of Science. It is further recommended that the General Committee so constituted should proceed to nominate two Boards to be associated with it in its decisions: one of these boards is to deal in particular with the Physical Sciences, and the other with the Biological Sciences. It was further recommended that each applicant for a grant should be required to furnish information as to the nature of the research in which he desires to engage and the scientific results expected to follow therefrom, the amount required and particulars of the proposed expenditure, whether he has received any previous grant from any source for the same object, and, if so, with what results, whether any portion of the grant is to be devoted to his own personal expenses, and what apparatus, if any, of permanent value he will require, so that any instruments already at the disposal of the Committee may be utilised. The Joint Committee also recommended that Grants be not made to other than British subjects, and that all Grants be made subject to certain specified conditions, amongst which are the following:—All instruments, specimens, objects or materials of permanent value, whether obtained by means of the grant or supplied from amongst those at the disposal of the Committee, are to be returned by the applicant at the conclusion of his research, or at such other time as the Committee may determine. Every recipient of a Grant must furnish annual reports containing a brief statement showing the stage that the enquiry has reached, an account of the expenditure incurred, a list of instruments or materials purchased or supplied, and references to any publications in which the results of the research have been printed. The constitution of the General Committee and Boards is still under consideration, but in the meanwhile it is proposed to allot a sum of £250 in Research Grants, and applications are invited, to be sent, in the first instance, to the Secretary of the Royal Society of South Africa, Cape Town, stating precisely the nature of the research, the amount of money required, and other necessary particulars.

TRANSACTIONS OF SOCIETIES.

Chemical, Metallurgical and Mining Society of South Africa.—Saturday, June 17th: Dr. J. Moir, M.A., F.C.S., President, in the chair.—"The testing of Transvaal coals": M. T. **Murray.** The author referred to the necessity of careful sampling, both from bulk and in the laboratory. Careful standardisation of the methods of testing with the bomb calorimeter, as regards radiation correction, oxygen pressure used, and in other respects he considered advisable, the bomb calorimeter, though admirable in itself, being liable to give discordant results in different hands. Methods of computation for corrections should be closely scrutinised in the light of experimental results. Such methods were being considered and tested by the author. The methods of procedure, he considered, should be standardised, and ultimate analyses of representative coals, together with analyses of their ashes, should be undertaken or financially aided by the Government.

Saturday, July 15th: Mr. H. A. White, Vice-President, in the chair.—"Notes on the treatment of mill concentrate": R. **Lindsay.** A description of the procedure adopted at the Geldenhuis Deep, Ltd. The daily scrape from the mills is ground in barrels, the fine product graded and caught in a two-compartment tank, whence it is transported from one compartment to the central amalgam room, and from the other to the reduction works for cyanide treatment. The cyaniding is carried on in a conical Crosse tank, and lasts in all twenty-four hours, at the end of which the concentrate residue assays 4 dwt. per ton. The concentrate plant, installed towards the end of 1910, cost £576, and by the end of May, 1911, gold to the value of £2,000 had been recovered by its means.—"Experiments in the treatment of accumulated ore slime by air-lift agitation": J. E. R. **Adendorff.** A record of experiments carried out with a view to determine the best method of treating accumulated acid ore slime in order to ascertain the rate at which gold dissolves in the cyanide solution. The conclusions arrived at were that success depended on maintaining a high alkalinity during the first three hours of aeration, and that lime should be added to the slime before treating with cyanide solution, so as to form a better protection for the free cyanide; also that lead acetate, when present, resulted in a better extraction of the gold. As to the rate of solubility of the gold in the accumulated slime in cyanide solution, more than 50 per cent. of the gold in the ore slime was found to pass into solution in the first hour.

South African Institute of Engineers.—Saturday, July 8th: Mr. F. H. Davis, President, in the chair.—"A system of soapy water lubrication for air cylinders": J. B. **Roberts**. The author, after pointing to the fact that compressed air, though the safest means of transmitting power, became actively dangerous under certain conditions, said that explosions in air compressors were becoming more prevalent. The causes of this were the presence of an explosive mixture, and an air temperature sufficiently high to ignite it, inferior lubricants being amongst these causes. Soapy water, if used systematically, is claimed to have the effect of preventing the deposition of carbon in the compressor cylinders and elsewhere, and so eliminating the possibility of flashing. The compressed air would thus also be free from carbon monoxide and other foul gases, and ensure a better atmosphere at the exhaust. The method of mixing the soapy water and applying it was then detailed.

South African Society of Civil Engineers.—Wednesday, July 12th: Col. G. T. Nicholson, M.I.C.E., President, in the chair.—"The Cape Town Main Drainage Scheme": H. S. **Perkins**. An account of the inception of the scheme and the carrying out of the works. The total cost of the scheme was about £274,000, and the average annual cost of maintenance, including the working expenses of the low-level areas, was about £2,000.

ADDRESSES WANTED.

The Assistant General Secretary (P.O. Box 1497, Cape Town) would be glad to receive the correct addresses of the following members, whose last-known addresses are given below:—

Aspland, C. Hatton, Witwatersrand Deep, Ltd., P.O. Box 5, Knight's, Transvaal.

Barton, Ernest Mortlock, Director of Works Department, Simonstown, Cape.

Bay, Dr. B., P.O. Box 5513, Johannesburg.

Bell, W. Reid, M.I.C.E., F.R. Met. Soc., M.I.E.S., P.O, Box 2263, Johannesburg.

Boulton, H. C., c/o Messrs. Pauling & Co., Ltd., Broken Hill, Rhodesia.

Brown, W. B., c/o Engineer-in-Chief, S.A. Railways, Cape Town.

Champion, Ivor Edward, P.O. Roberts Heights, Pretoria.

Crockett, John, 10, Transvaal Bank Buildings, Johannesburg.

Dickie, Andrew, 475, Currie Road, Durban, Natal.

Leech, Dr. J. R., 4th Avenue, Melville, Johannesburg.

Macfarlane, Donald, M.I.C.E., H.M. Naval Dockyard, Simonstown, Cape.

Mirrilees, W. J., 9, London Chambers, Durban.

Nichol, Thomas Thompson, P.O. Box 34, Springs, Transvaal.

Nicholas, W. H., Durban High School, Durban, Natal.

Nicholson, J. Greg, Leliefontein, Government School, P.O. Carolina, Transvaal.

Petersen, H. T., P.O. Box 5, Cleveland, Transvaal.

Preston, James, 89, Arnold Road, Observatory, near Cape Town.

Southwell, Miss Jessie, 270, Visagie Street, Pretoria.

Van Oordt, J. F., Harrismith, O.F.S.


Yours faithfully

HARRY BOLUS,

D.Sc., F.L.S.

(1834-1911.)

Harry Bolus was born in Nottingham on April 28th, 1834. He was the second son of Joseph Bolus, a business man of that town and a Unitarian. He received his early education in the Nottingham Castle Gate School under Mr. George Herbert. At the age of $15\frac{1}{2}$ he came to South Africa as an apprentice articled to Mr. William Kensit, a merchant of Grahamstown, and a friend of his schoolmaster, through whom the connection was established. At school he is known to have been a diligent and successful student and a favourite with his teacher. The instinct of the collector appears to have been developed early. While still at school he collected various natural objects, but was more particularly interested in insects. A much-used copy of the 1848 edition of W. B. Carpenter's "Animal Physiology," believed to have been presented to him by Mr. Herbert, is preserved in his library. There is still in existence a signed copy of a compact made between Bolus and two of his schoolfellows with regard to the ordering of their lives. They contract not to use alcohol nor tobacco until they severally attain the age of 21 years. They accept the principle that

"next to moral and religious duties the pursuit of science is one of the noblest objects that can engage the attention of the human mind."

and proceed to apportion to each a particular line of study, the pursuit of which he promises to make one of the objects of his life. Botany falls to one of them, but not to Bolus, who undertakes as his subject "The Terrestrial Sphere as exhibiting in its history, structure and preservation the omnipotence of its Creator." This document is signed in 1851—after Bolus had left England for South Africa. In this case a love for Botany was not to be developed until he reached more mature years, but already in his schooldays he feels the appeal of the phenomena of Nature.

On the voyage to South Africa he kept a diary primarily for the information of his mother. It is a small octavo volume of rather more than a hundred pages of manuscript, among which are a few excellent pencil sketches. It is written in that bold and neat hand which, but slightly altered in character, became so familiar to his many botanical correspondents of later years. It is entitled "Journal of a Voyage to the Cape of Good Hope in the Barque *Jane*, 300 tons, J. C. Gales, Commander, bound to Algoa Bay." On Wednesday, 12th December, 1849, the *Jane* was "hauled out of the Wapping Basin, London Docks, at 12.30 p.m."

On Monday, March 18th, he writes:—

"This morning early tacked once or twice to the anchorage (Algoa Bay). . . . Thus ended what was, I think, one of the most pleasant voyages ever sailed; everything being novel to me gave a great charm to the time, which passed quickly, though it was long, being exactly ninety-four days."

On each of these ninety-four days he notes, evidently with great care and precision, the latitude, longitude, course and distance travelled. On January 8th "We first noticed the barometer and thermometer, of which I shall henceforth give account." He observes besides many things of interest:

"Off the Cape Verde we noticed that our sails and rigging were covered with a fine red-looking sand. The Captain says it regularly occurs here with the trades, and is blown from the sandy shores of Africa. It makes the atmosphere quite hazy and thick for a few days, and is, I think, a remarkable phenomenon."

The dolphins, sharks, flying-fish and birds received their meed of attention, and their habits are carefully recorded. The methods of harpooning the porpoises are described, and of one so secured, "I cleaned and dried the jaws with teeth complete." Less conspicuous forms of animal life were seen, in particular abundance off Tristan d'Acunha, and the forms of some are sketched. The ordinary time-passing occupations of a long voyage, the same to-day as sixty years ago, were resorted to, and in addition he entered keenly into the more practical life of the ship. He learned to steer; assisted the officers in taking the daily observations; having climbed the lower masts, he writes:—

"I mustered up courage sufficient to take me up to the top-gallant yard. I am ambitious to achieve the utmost by ascending to the main truck or royal mast-head; of this I will advise you duly."

A day later his ambition in this direction was satisfied. On February 9 we are told:—

"I employ myself just now in teaching one of the apprentices forward Mr. H[erbert]'s system of running hand. He does very well, and rapidly improves."

In this early record we have a picture of a youth endowed with energy, enthusiasm and determination, a good physique, steady nerves, an active, methodical and well-balanced mind, keen powers of observation, the habit of recording what he saw, the ability to adapt himself to his immediate circumstances, and a readiness to help others less happily situated than himself.

Landed in Port Elizabeth, he proceeded by ox-wagon to Grahamstown—"a pleasant journey of six days over 96 miles"—arriving there on 28th March, 1850—"being exactly 106 days from the Docks."

His business career at Grahamstown was interrupted by the outbreak, in December, 1850, of the Eighth Kaffir War, in which he saw active service. Two years later his engagement with Mr. Kensit was dissolved, and he became bookkeeper in a mercantile house at Port Elizabeth, in which position he remained until 1855, when he paid a short visit to England. The end of that year found him at Graaff-Reinet, which became his home for nearly twenty years.

His first position at Graaff-Reinet was that of Secretary to the Graaff-Reinet Board of Executors. His connection with this Society was of short duration; he then became Secretary of the Midland Fire Insurance and Trust Company, in whose foundation he took a prominent part. He became interested in the *Graaff-Reinet Herald*, a weekly newspaper, whose columns during this period contain many contributions from his pen. In 1857 he married the sister of his former chief, Mr William Kensit. Four years later the foundation of the Graaff-Reinet College brought him into touch with Professor F. Guthrie, one of the first-appointed members of the staff of that institution. This acquaintance developed into friendship, which exercised a powerful influence upon the lives of both. It sustained some interruption on the departure of Bolus for Cape Town in 1874, but was resumed on its old footing four years later, when Guthrie became Professor of Mathematics in the South African College. They were both prominent in the intellectual as well as in the business affairs of Graaff-Reinet. In August, 1862, Bolus delivered an admirable address on "The Uses of Recreation"* at a soirée of the local Athenæum. In August, 1874, Bolus and Guthrie were entertained at a public banquet in recognition of the valuable aid they had jointly rendered the community in connection with the passing of the Graaff-Reinet Railway Bill†.

In 1862 Guthrie delivered a short course of public lectures on Botany. An article in the *Herald*‡, which there can be little doubt was written by Bolus, gives the following account of them:

"They were strictly scientific, while at the same time so much useful information was conveyed as to gratify the more youthful part of the audience and those to whom the nomenclature alone might have proved too dry a study at seven in the morning." . . . [Prof. Guthrie has] "a remarkable clearness and precision in his language. . . . It is the best evidence of Prof. Guthrie's success in this effort when we state that some persons who at first attended the course with but little interest in the subject soon found their attention awakened and, as the lecturer proceeded, confessed themselves irresistibly compelled to pursue the study."

It is understood that Bolus was regular and persistent in his attendance at this course, and we may conclude that he himself

* Printed in full in the *Graaff-Reinet Herald*, August 16th, 1862.

† A testimonial presented by the inhabitants of Graaff-Reinet to Bolus and Guthrie on this occasion includes the following:—

"We feel that it is mainly owing to your exertions that so much valuable information was gathered, and that statistics were so carefully compiled as to show clearly that Graaff-Reinet at least had an urgent claim upon the Government for a direct railway to its natural seaport, and so distinctly was this proved that, although deviations from some of the lines proposed by the Government were suggested, the line from Port Elizabeth to Graaff-Reinet was carried without the least discussion."

‡ December 20th, 1862.

was one of those who "were irresistibly compelled to pursue the study." It was to some extent due to Guthrie's influence that in 1865, when prostrated by the death of his eldest son, Bolus sought solace in the study of botany, which henceforward was his ruling passion. Subsequently he became a member of the Committee of the Botanic Garden; a proof of the interest which he took in its welfare is found in a sub-leader in *The Herald* of January 12th, 1875, which opens with the lament, "Mr. McLea is gone. So is Mr. Bolus. What is to become of the Botanical Garden?"

The study of botany, once commenced, was pursued in that thorough and efficient manner which characterised all his undertakings. His note-books of the period are filled with technical descriptions, detailed drawings of dissections and lists of his determinations, the evidences of a self-imposed course of training to which must be largely attributed the scrupulous accuracy which distinguishes all his botanical work. His first Herbarium cabinet was made in August, 1865. In 1867 he commenced a life-long correspondence with Kew. Of the many friends he made at Kew, an institution to which he was greatly attached, the earliest were Sir Joseph Hooker and Professor Daniel Oliver, whose assistance in his botanical work he valued very highly, and whose friendship was among the joys of his later life. To improve a weak knowledge of German he translated and afterwards published* an English rendering of Meyer's "Commentarii de Plantis Africæ Australioris." In 1869 he reviewed† the second edition of Harvey's "Genera of South African Plants" in a manner which showed how carefully he had studied the existing literature of South African botany.

At this time the study of Botany in South Africa was in its infancy. What MacOwan has called "the period of the great collectors" was ended. Thunberg, Burchell, Drège, Ecklon and Zeyher had made their famous journeys, and their collections were only partially investigated. The "Thesaurus Capensis" was recently completed, and the third volume of the "Flora Capensis" had just appeared. MacOwan was at work at Somerset East. Pappe's Herbarium had commenced its chequered existence, and shortly afterwards was said to be "in such a state of neglect and inaccessibility as to be a discredit to the Colony."‡ Writing in 1869, Bolus§ gives the following account of the botanical situation:—

"At present these [observers] are few. A small knot of students in the Eastern Province have already commenced the work; but two centres only—Grahamstown and Graaff-Reinet—have as yet been well explored. To these, others are now being added, as Colesberg, Hopetown, Seymour (in the Katberg) and Kingwilliamstown. Something is now known of the country between the sea and the Sneeuwbergen, Bosch-

* *Cape Monthly Magazine*, 1873-74.

† *The South African Magazine*, vol. iii (1869).

‡ *Graaff-Reinet Herald*, April 11, 1874.

§ *The South African Magazine*, vol iii (1869).

berg and Amatola Ranges. But north of these we are sadly ignorant. The records of the earlier collectors over that vast plateau, stretching from Victoria West to the Wittebergen, will indeed be of service. . . . Observers and collectors are still to be wished for at Cradock, Queenstown, Burghersdorp, Aliwal, Richmond, etc., and over the whole Western Province." And, quoting another writer, he adds: 'At present all the botanists are Easterns, without exception. . . . Hitherto it has been easy to procure botanical materials from China and Japan, from New Zealand and Feejee, but not from Table Mountain.'"

Such was the state of the kingdom into which Bolus entered.

In the review just quoted, Bolus indicates the lines along which botanical investigation should proceed in South Africa, emphasises the greater opportunities of the resident as compared with those of the traveller, and states his willingness to correspond with "anyone with a taste for Natural History." This led to an extensive botanical correspondence, which he maintained until the end. In a letter written a few weeks before his death he is able to say that "over the whole of South Africa, from the Cape Peninsula to the Transvaal and even to Basutoland, there have been isolated workers engaged in collecting and investigating the flora of the country, stimulated and assisted, so far as may be, by students in the more populous centres of the southern coast." It was to himself that a large proportion of these isolated workers looked for stimulation and assistance, and he was never too busy to give them of his best. It is not possible to doubt that the work which he did in this way, which made little show and was usually unnoticed save by those immediately concerned, has been productive of a great extension of the interest in botanical pursuits throughout the country and of an unmeasured addition to our knowledge of its vegetation.

In 1874 Bolus severed his connection with Graaff-Reinet and entered into partnership with his brother, a stock-broker in Cape Town. He ceased to take an active share in the business in 1895. He was thus brought into the Western Province, whose botany had hitherto been so signally neglected, and in which the most productive of his labours were to be spent. He settled first at Rosebank, where his herbarium was once placed in jeopardy by the burning of the thatched roof of his house. For five years he lived in a house facing the main road near the fountain at Rondebosch. Meantime he built the house at Sherwood, Kenilworth, into which he moved in March, 1887, and which was his home for the rest of his life.

Soon after settling at the Cape—in 1876—he paid the first of a series of visits to Kew. He took with him a large number of specimens from his herbarium for comparison with the Kew types. He made this a practice in successive visits, and to this is due in a very large measure the unique position which the Bolus herbarium holds among South African collections. On returning to the Cape after his first visit, he was pursued by misfortune; his boat, the *Windsor Castle*, was wrecked on Dassen Island, and all his plants were lost. Fortunately he had deposited duplicates at Kew. Shortly after his return he began to take a special interest in orchids, a group marvellously represented in South Africa, and which henceforward claimed perhaps the largest share of his attention. As a preliminary to this life-study he prepared at Kew in 1881 a list of the Cape orchids already known*. In 1882 he published descriptions of the Cape Peninsula orchids (117 species), illustrated by 36 plates drawn and coloured by himself†. In 1893 the first part of the first volume of the "Icones Orchidearum Austro-Africanum Extratropicarum," containing 50 plates, was published. A second set of 50 descriptions and plates appeared three years later. The second volume, containing 100 plates, was issued a few weeks after his death, the last proof-sheets having been revised by the author on the last day of his life. Rather more than 50 drawings yet to be published will complete a permanent record of the skill, enthusiasm and devotion with which he laboured at this difficult group for more than thirty years.

He took a very sane view of species-making, and regarded it as a necessary preliminary to the further study of the vegetation, which can only commence when the species are properly known and tabulated. In a newly-occupied country in which vast areas have been as yet but little affected by the destructive presence of the European, the problems of geographical distribution force themselves upon the notice of the student. As early as 1873, he writes:—

> "As the knowledge of the species of plants which inhabit any country becomes more accurate, so does it become possible to trace their relations with those of other similarly known countries; and in the study of the physical conditions, past and present, of such countries, to ascertain the laws which govern the distribution of plants over the earth's surface."‡

To these problems he gave his careful attention very early in his botanical career. Having studied the writings of his predecessors, and himself made extensive botanical explorations in the environment of Graaff-Reinet, in Little Namaqualand, and in the Western Province, he published in 1886 a sketch of the flora of South Africa§, which was at once accepted as the standard treatise on the subject. Sir Joseph Hooker, reviewing this work¶, wrote:—

> "The attempt to define the South African regions of vegetation is not a new one; . . . the author of the sketch under consideration is the first who has succeeded in presenting satisfactorily the salient botanical characters of that flora as affected by, or in correspondence with, geographical and other physical conditions whilst he alone has

* *Journal of the Linnean Society*, vol. xix (1882).

† Trans. S. A. Phil. Soc., 1882.

‡ *Cape Monthly Magazine*, 1873. [Translator's Introductory Remarks to translation of E. Meyer's "Commentaires."].

§ Official Handbook of the Cape of Good Hope, Cape Town, 1886. (Reprinted in the "Illustrated Handbook of the Cape and South Africa," in 1893.

¶ *Nature*, May 27, 1886.

given such vivid pictures of the different botanical regions he has defined hat anyone with even an elementary knowledge of South African plants can fancy himself travelling over the same ground."

The "Sketch of the Floral Regions of South Africa,"* published in 1905, is a masterly summary of the main points of the paper of 1886, in which certain modifications of the original scheme of subdivision are introduced."

He collaborated with Major Wolley Dod, R.A., in the preparation of "A List of the Flowering Plants and Ferns of the Cape Peninsula, with Notes on the Critical Species," which appeared in 1903†. Bolus contributed an introduction of 22 pages, which contains a valuable discussion of various geographical and floristic problems. This work, the first "Catalogue of the plants found upon the Cape Peninsula, the portion of the Colony earliest known and colonised, and that still containing the largest population," will no doubt lead to the preparation of a Peninsula flora for popular use.

In conjunction with his old friend Guthrie, he commenced in 1894 the elaboration of the heaths for the "Flora Capensis." Their joint labours were interrupted by the death of Guthrie in October, 1899, an event which was keenly felt by the survivor. More than 300 pages of the fourth volume of the "Flora Capensis" (published 1905) are filled with the descriptions of the 469 species of Erica which are endemic in South Africa.

Such is a bare summary of what will perhaps rank as the principal botanical achievements of a man who, one would think almost unknown to himself, has played a great part in the establishment of botany as a science in South Africa.

But Bolus was not merely a botanist. He was widely read in English prose and poetry. He had a keen appreciation of pictures; the last Saturday of his life was spent at the exhibition of the Royal Academy. He was intensely interested in education, and when he wrote in the preamble to his will,

> "Education in its widest sense should be recognised as the best means for the improvement and welfare of mankind, and therefore as the best means of promoting the public good,"

he was professing a doctrine which he had consistently practised since the time when he taught the ship's apprentice Mr. Herbert's system of running land. Much of what he did for the advancement of education is not generally known. Among his more public acts are the encouragement and assistance which he gave in the foundation of the Harry Bolus Chair of Botany in the South African College in 1902, and his munificent bequest for the endowment of the Bolus Scholarships at the same institution. From 1897 until his death he was a member of the Board of Directors of the South African Public Library; in 1906 he became trustee of the South African Museum. In 1908 he was appointed a member of the Council of the South African College, in the affairs of which he took an active interest until, in 1910,

* "Science in South Africa," Cape Town, 1905.

† Trans. S.A. Phil. Soc., 1903.

his decreasing strength compelled him to resign. The South African College is now charged with the maintenance and extension of his herbarium and botanical library, whose formation engaged so large a share of his activity during many years, and for the endowment of which a considerable part of his fortune is set aside.

He became a Fellow of the Linnean Society in 1873 In 1874 he was appointed a Justice of the Peace in the division of Graaff-Reinet. He filled the office of President of the South African Philosophical Society in the session 1886-87, and was an original Fellow and Member of Council of the Royal Society of South Africa, which he served as Treasurer, 1908-09. In 1903 he received the honorary degree of D.Sc. from the Cape University. In 1909 he was awarded the South Africa Medal and Grant for Scientific Research by the South African Association for the Advancement of Science.

He left Cape Town for England on April 24th. He died at Oxted, in Surrey, in the early morning of May 25th. He is buried in the churchyard at Oxted.

Harry Bolus was a man of strict integrity and unflinching candour. He was disinclined to take an active part in public affairs, but, having allowed himself to be charged with them, he felt keenly the weight of responsibility. He was generous by nature, but when acting in the public behalf he was firmly convinced that his first duty was to be just. He possessed great strength of character, and having made up his mind as to the propriety of a course of action, he followed it without hesitation or deviation. His affections were strong, and at all periods of his life he appears to have made great rather than many friends. Two or three of his schoolfellows were affectionately remembered after more than half a century of separation. In his later life comparatively few were admitted to terms of close intimacy, but the bonds which united these to himself were of the firmest, and were broken only by death. He loved the society of those whose interests accorded with his own. He was retiring by nature, and inclined to depreciate his own achievements; it may be that the men of his own time have not yet fully recognised the value of the work he has done in the country of his adoption. But his name will be held in grateful remembrance by future generations of South African students, and in the annals of South African Botany it will be enrolled with those of Thunberg and Burchell and others of his distinguished predecessors who prepared the ground for the foundations which he laid.

* * * * *

The writer is indebted to Mr. H. H. Bolus and to Miss H. M. L. Kensit for information which without their aid would have been inaccessible. Miss Kensit has kindly prepared a list of the principal botanical journeys made by Dr. Bolus, which is printed as Appendix I.

H.H.W.P.

Appendix I.

Botanical Journeys.

1866, March. From Graaff-Reinet to Somerset East.
1866-67, Dec.-Jan. From Graaff-Reinet to Port Elizabeth, Uitenhage, Mimosa Dale, Witte Klip range, Van Staden's River Gorge and Eland's River Mts.
1867, Oct.-Nov. To Somerset East, summit of Boschberg (4,880 feet) and Bruintjes Hoogte (5,770 feet).
1867, Dec. From Graaff-Reinet to Zuurpoort, Murraysburg, Sneeuwbergen and summit of Oudeberg (5,680 feet).
1868, April. To the summit of Sneeuwberg, Spitzkop, Compassberg (8,700 feet), Oudeberg (5,680 feet), and Houd Constant.
1869, June. To Richmond, Hanover and Murraysburg.
1870, March. To the summit of Tandjesberg (5,000 feet).
1870, Nov. 20th-Dec. 12th. From Graaff-Reinet, through Aberdeen, Willowmore, Uniondale, Avontuur, Knysna, Long Kloof, Kromme River Valley, Humansdorp, Kabeljauw's River, Gamtoos River, Van Staaden's River and Port Elizabeth.
1871, Feb. From Graaff-Reinet to Hanover, Colesberg and Richmond.
1872, June 5th-21st. From Graaff-Reinet to Somerset East, Grahamstown and Port Elizabeth.
1873, Jan. To the Koudeveld.
1873, April. Ascent of the Gnadouwsberg (7,000 feet).
1878, Oct. To Malmesbury, Groen Kloof and Mamre.
1879, Jan. To Worcester and Hex River Valley.
1879, Nov. 10th-25th. To Tulbagh Valley, Summit of the Winterhoek Mt. (6,818 feet), Mitchell's Pass, Waverley Mills, Darling Bridge, Worcester, Brand Vlei, Villiersdorp, Houw Hoek, Palmiet River, and Sir Lowry's Pass.
1880, Jan 1st.-3rd. To Wellington and Du Toit's Kloof.
1883, Aug. 18th-Oct 4th. Namaqualand: From Port Nolloth through Oograbies Poort, Annenous, Klipfontein, Kasteel's Poort, Kookfontein, Zwaart Bult and Paddegat, Garrakoop Poort, O'okiep, Nababeep, Modderfontein, Springbokfontein, Spektakel Mt., Ezelsfontein, 'Naries and Tweefontein.
1884, Nov. 10th-23rd. To Orange River Station, Kimberley and Barkly West.
1885, Jan. 17th-23rd. To Caledon, Genadendal and summit of Genadendal Mt.
1885, Oct. 2nd-5th. To Houw Hoek and summit of Houw Hoek Mt.
1885-1886, Dec. 18th-Jan. 13th. To Ceres, Touw's River, Bedford, summit of Kagaberg, Cookhouse, Grahamstown, Coldstream, Lower Albany, Port Elizabeth, Emerald Hill, and Graaff-Reinet (for ascent of the Oudeberg).
1886, April 21st-28th. To the Gouph, Nieuwveld and Fraserburg.
1886, July 31st-Oct. 13th. From Delagoa Bay through Ma-ting-a-ting, Komatie River Drift, Louw's Spruit, Honeybird Creek to Barberton, Devil's Kantoor, Eland's River, Venner's Poort, Burg Spruit, Zwart Koppies, Pretoria, Potchefstroom, Kimberley and Bultfontein.
1887, April 4th-11th. To Worcester, Robertson and Swellendam.
1887, Oct. 1st-4th. To French Hoek Mts.
1888, Jan. 4th-14th. From Beaufort West to Fraserburg, Touw's River Station, Hex River East to Ceres and the Gydouw.
1889, Oct. 1st-8th. To Ceres, the Gydouw and Cold Bokkeveld.
1890, Jan. 9th-18th. To Swellendam, Zuurbraak and Tradouw Pass.
1890, Oct. 30th-Nov. 17th. To Grahamstown, Port Elizabeth and Graaff-Reinet.
1891, Dec. 12th-23rd. To Ceres and the Koude Bokkeveld.
1892, Sept. 30th-Oct. 10th. To Piquetberg.
1892-1893, Dec. 26th-Jan. 4th. To Montagu Baths.

1893, Nov. 3rd. To Caledon and Hermanus.
1893-1894, Dec. 21st-Jan. 11th. Orange Free State—From Bloemfontein to Bethleham, Bester's Vallei, Witzie's Hoek and the country round the Mount-aux-Sources.
1894. Sept. 29th. To Caledon and Elim Mission Station.
1895, Sept. To Goedverwacht (Piquetberg District).
1895-1896, Dec. 29th-Feb. 25th. To Komgha, Engcobo, Cala, Maclear, Tsolo, Umtata, St. John's River Mouth, and Queenstown.
1897, Jan. 10th-20th. To Mossel Bay and George.
1897, Sept.29th. To Clanwilliam and Wupperthal.
1899, Jan. To Grahamstown, Port Elizabeth, Witteklip, Zuurberg, Komgha and Kingwilliamstown.
1904. Feb. 12th-March 6th. To Bloemfontein, Johannesburg, Pretoria, Pietersburg, Houtbosch and Potgieter's Rust.
1904. Oct. 20th-31st. Riversdale and Garcia's Pass.
1904, Sept. 1st-18th. To Hopefield, Hoetjes Bay (Saldanha Bay) and Darling.
1905-1906, Nov. 27th-Jan. 25th. To Prince Albert, Zwartberg Pass, Oudtshoorn, Robinson's Pass, Graaff-Reinet, Pretoria, Belfast, Carolina, Swaziland, Wonderfontein and Warm Bath.

Appendix II.

Published Botanical Writings.

1869. Botany at the Cape. (Review of the second edition of Harvey's Genera of South African Plants.) The South African Magazine, vol. iii.
1873-4. On the Geographical Distribution of Plants in South Africa (being a translation of E. Meyer's "Commentaires," with an Introduction and Notes by the translator). Cape Monthly Magazine, 1873-1874 (seven articles).
1881. Contributions to South African Botany (with P. MacOwan). Journal Linnean Society, vol. xviii.
1882. List of published species of Cape Orchids. Journal Linnean Society, vol. xix.
1882. A Catalogue of printed Books and Papers relating to South Africa with P. MacOwan). Part I. Botany. Transactions South African Philosophical Society.
1884. Contributions to South African Botany (Orchideæ). Journal Linnean Society, vol. xx.
1885. Contributions to South African Botany (Orchideæ). Journal Linnean Society, vol. xxii.
1886. The Flora of South Africa. Official Handbook of the Cape of Good Hope.
1887. Contributions to South African Botany (Orchideæ). Journal Linnean Societey, vol. xxiii.
1888. Contributions to South African Botany (Orchideæ). Journal Linnean Society, vol. xxv.
1888. Orchids of the Cape Peninsula (with thirty-six plates). Transactions South African Philosophical Society.
1890. Contributions to South African Botany (Orchideæ, including a revised list of published species of extra-tropical South African Orchids). Journal Linnean Society, vol. xxv.
1893. *Icones Orchidearum Austro-Africanarum extra-tropicarum,* vol. i. Part I. (with fifty plates).
1894. Contributions to the Flora of South Africa. (Ericaceæ.) Journal of Botany, vol. xxxiii.
1894. On the Genus Acrolophia (with R. Schlechter). Journal of Botany.

1896. Contributions to the Flora of South Africa. Journal of Botany. vol. xxxiv.
1896. *Icones Orchidearum Austro-Africanarum extra-tropicarum,* vol. i. Part II. (with fifty plates).
1903. A List of the Flowering Plants and Ferns of the Cape Peninsula, with notes on some of the critical species (with A. H. Wolley Dod). Transactions South African Philosophical Society.
1905. Sketch of the Floral Regions of South Africa. Science in South Africa: A handbook and review.
1905. The Genus *Erica* (in part with F. Guthrie). Flora Capensis. vol. iv.
1905. Contributions to the South African Flora. Transactions South African Philosophical Society, vol. xvi.
1906. Contributions to the African Flora. Transactions South African Philosophical Society, vol. xvi.
1907. Contributions to the African Flora. Transactions South African Philosophical Society, vol. xviii.
1909. Contributions to the African Flora (with L. Kensit). Transactions Royal Society of South Africa, vol. i.
1909. A new Cissus from the Transvaal. Journal of Botany, vol. xlvii.
1911. *Icones Orchidearum Austro-Africanarum, extra-tropicarum,* vol. ii, (100 plates).
[Unpublished—*Icones Orchidearum Austro-Africanarum, extra-tropicarum,* vol. iii (*circa* 40 plates).]

UTILISATION OF WATTLE BARK.—In the latest Bulletin of the Imperial Institute (Vol. 9, No. 2) special attention is drawn to the value of wattle bark for tanning, and to the increasing production of this material in Southern Africa. Emphasis is also laid on its relative cheapness. Recently a number of analyses of black wattle barks obtained from Natal, the Cape Province, the East Africa Protectorate, and Australia were made in the laboratories of the Imperial Institute, and the following percentages of tannin were found: Natal, 35.2 to 39.8; Cape, 40.1 to 44.1; East Africa, 36.7 to 42.1; Australia, 38.3. All these barks are rich in tannin, and they posses the additional advantage of containing only small proportions of non-tannin extractive matter. The tannin in wattle bark is, moreover, easily extracted, and the liquors prepared from the bark lose comparatively little in strength when kept. The quality of the bark on the market is stated to show but little variation, and owing to increasing production there is no danger of a failure in supply. For the production of heavy leathers Paessler considers wattle bark superior to all other tanning materials except Quebracho wood.

NOTES ON THE EAST COAST BANTU OF EIGHTY YEARS AGO.

By William Hammond Tooke.

I. Tonga.

In 1822 the British Government dispatched two vessels of war to the Indian Ocean on a cruise of survey and observation of the East Coast of Africa, the coast of Muskat, Madagascar, the Seychelles, and other islands in the Indian Ocean. This service was carried out by His Majesty's ships *Leven* and *Barracouta*, commanded by a distinguished officer, Captain William Fitzwilliam W. Owen, under great difficulties, owing mainly to the deadly nature, in those days, of the East Coast malarial fever; and it was, after the greater number of the crews had fallen victims of the disease, completed in 1825.

The account of this cruise* gives some interesting information relative to the geography and ethnology of the country round Delagoa Bay and other portions of the South-East African coast in the early portion of the last century.

At that time the country was inhabited by a number of tribes who spoke, from Maputa on the South of the bay to as far north as Inhambane, what may be considered as one speech, to which Dr. Bleek subsequently gave the name of Tekeza (a Zulu epithet derived from "tekeza, teketa," "childish prattle"), but which is now more generally known as the Tonga (Thonga) or Inhambane language group. For it is found to comprise various dialects, known to us (principally through the indefatigable labours and researches of M. Henri A. Junod, of the Swiss Mission at Rikatla, Lourenço Marques) as the Hlengwe, the Nwalungo, the Jonga, the Ronga, the Hlangenu, and the Bila dialects.†

This Tonga or Thonga group must be distinguished from the Ba-Toka or Ba-Tonga of the Middle Zambesi basin, and also from the Ba-Tonga (probably an outlying branch of that tribe), who in the sixteenth century occupied a region lying south of Sena. At that date the tribes of the Thonga group lived in what was then called Otongwe under their chief Gamba, who was again subject to the Monomotapa's vassal Sedanda; and the Jesuit missionaries spoke of them as Botonga. Otongwe is now known as Inhambane, and is therefore far distant from the Sena district occupied by the Ba-Tonga. There is nowadays a marked distinction between the Zambesi basin and the East Coast Tonga languages; that of the interior is the most archaic, and has thirteen noun-classes as compared with eight in use among the tribes of the littoral. Yet place-names like Pafuri and Panyele

* "Narrative of Voyages to explore the Shores of Africa, Arabia and Madagascar, performed in H.M. ships *Leven* and *Barracouta*"; London, 1833.

† See M Junod's "Grammaire Ronga," "La Langue et la Tribu thonga;" Lausanne, 1896.

(both south of Limpopo) seem to point to the fact that in earlier days the languages were identical, and that formerly the coast dialects had, but have since lost, a locative case with a class prefix still existing among the Central African Ba-Tonga.

M. Junod tells us that the inhabitants of the coast between San Lucia Bay and Inhambane consisted originally of an indigenous primitive Bantu population, who were unacquainted with the use of iron. At a later date it was subjected to invasions of other tribes, some from the north, others from the south. Of these, immigrating from the north, that speaking the Hlengwe dialect seem to have been the first in the field—a rude tribe that was even ignorant how to kindle fire. Pushing out the aboriginal Ntimba and Chilambo, Tchpoi and Tsonga tribes, they settled on the east (left) bank of the Limpopo; and from them sprang the Ma-Kwakwa and Inhambane (Nyamban) clans, the Hlengwe of Chigombe and the Hlengwe of Madzibe.

Another horde, the Ba-Loyi, were evidently akin to the Ba-Luyi or Lea-Luyi of Coillard; that is, the tribe variously known in different dialects at Ma-Rotse, Ba-Ruyi, Aa-Lui, Aba-Lozi, Ba-Lozwe and Ba-Rotse, now living in Lealuyi, the swamps of the Upper Zambesi, under their king Lewanika. Both Livingstone and Father Torrend have held the view that these Ba-Loyi or Ba-Rotse are closely allied to the neighbouring Ba-Lunda or Ba-Runda on physical and linguistic grounds; while MM. Junod and Coillard unite in tracing them back to the Ba-Nyai and Ma-Kalanga. The Ba-Loyi of Lealuyi claim to have come from the east, *i.e.*, Mashonaland or Banyailand; the branch of Ba-Loyi which has come east and become a branch of the Tonga group uses "*Munyai!*" as the form of salutation; but it speaks a Thonga dialect known as Nwalungo, and occupies a tract bounded by the Olifant and Limpopo Rivers and the Longwe Mountains. The adjoining Ma-Luleke clan also speak Nwalungo.

Another East Coast tribe of Central African origin are the Tembe, or, as Perestrello called them in 1554, Zembe. Like the Ba-Loyi, they were of Kalanga origin, as their salutation "*Nkalanga!*" shows. Dr. Livingstone tells us* that the people of Cazembe (Ka-Zembe) were Ba-Loi or Ba-Lunda, and their country Bailunda, Lunda or Lui, so called by the Portuguese. It seems clear, therefore, that in times past the Ba-Loyi and Ba-Lunda were closely related and the terms interchangeable, and that they were connected with Perestrello's Zembe.

In the sixteenth century the Zembe or Tembe dwelt south and west of the Limpopo and in the Lower Komati basin. At a still earlier period, according to tribal traditions, they once lived on the confluence of the Limpopo and the Pafuri. In 1554 the kingdom of Tembe was situated north of Delagoa Bay, between it and the Limpopo River, which formed the northern boundary. The successive chiefs or "*Kapelas*," as they were called, lived until the eighteenth century in amity with, but independent of, the Portuguese, and carried on a trade with them in ivory and

* "Missionary Travels," p. 306.

ambergris. But during this period they had worked round to the south as far as the basin of the Maputa River, to which, apparently, they gave their name; for the Maputa was formerly known as the Tembe or Temby River, a name now given to a smaller river on the east.

Offshoots of the Tembe are the Ma-Puata, the Ma-Tolo and the Ma-Nkura, classed linguistically as Ba-Ronga, and speaking a Si-Ronga dialect.

In the "Narrative" the kingdom of Temby

"is bounded by the Bay and the River Mapoota on the east, north by the English and Dundas Rivers, west by the mountains of the Olontontes or Vatwahs* southwards by the little state of Pengelly † and south-east by the kingdom of Mapoota."

In his report to the Admiralty, Captain Owen says:—

"The people of this kingdom [Tembe] are timid, tractable, industrious, keen in traffic and treacherous, it is said, where their interest prompts, or a temptation is in their way. With these people we had more intercourse than any others . . . They are precisely the same people as those of Mapoota and Inyak, and all round the Bay, all speaking the same language, I believe, as far as Inhambane."‡

This means, of course, as just explained, that they all belong to the Tonga Language group.

The Ma-Puta, offshoots of the Tembe tribe, subsequently gave their name to what was once the Tembe, but is now the Maputo or Usutu River. The Ma-Puta chief held the title of Inyaka (Inhaca), to which the Inyak Islands owe their name.

"The eastern peninsula of the great bay and the island named by the Portuguese St. Mary are known by the natives as Inyack and Litt e Inyack (i.e., the Inyaka's territory), and are now both subject to Mapoota."§

In his report above referred to, which is dated 23rd May, 1822, Captain Owen says:—

"Mapoota is bounded north by Delagoa Bay, north-west by the kingdom of Temby, south by the kingdom of the Vatwahs or Olontotes, a very warlike and admirable race of Kaffirs."

In the "Narrative" Maputa is described as the "oil country," situated southward of the great bay of Delagoa, bounded by a fine navigable river on the west which separates it from Panegela (Panyele). This river is the Maputa or Usutu.

"It forms a portion of Temby, the dominion of King Kapell, which extends entirely from the English and Dundas Rivers on the north."¶

This territory includes what was later known politically as Tongaland, the lands of Umbigiza and Zambane.

"Matoll [continues the 'Narrative'] is on the northern branch of the river of that name which empties into the English River [the southern boundary was apparently the Dundas River]. Northward of Matoll lies Moamba, a very considerable state. Mabote, Mamalong, Maghoy, Cherinda are small states at the mouth of King George [river], but Manyess and Mamalong on the western bank are now settled by the Vatwahs."

The Manyess or Manisa River derives its name from the Ma-Nisa tribe which formerly occupied its banks. The name

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* A tribe of which we will speak later.

† Panyele.

‡ Theal's "Records of South East Africa," vol. i, p 469.

§ From the "Narrative."

¶ *Ibid.*

"Moamba" reminds us of the great Abambo tribe of Natal (Embo) of which it was probably a section. It was a chief Mambe who had communication with the Dutch when they entered Delagoa Bay in 1726, and a "king" Wamba who in 1798 robbed Mafumo of the greater part of his territory.

It is probably, also, something more than a coincidence that Mamba was the dynastic title of the Kalanga chief, a great potentate who kept tame lions and elephants, and who was destroyed (flayed alive, the story goes) some three hundred years ago at his great place, Thabas Mamba (Mamba's Mount), near Gwelo, by the Barotse invaders. A section of Makaranga, according to native tradition, moved south to "Embo," some three or four hundred years ago, driven down by the Ba-Venda; and with them, if not of them, the two chief clans of the Abambo, the Ama-Zizi and Ama-Hlubi. It may be remembered that Father Fernandes, writing in 1560 to the Father Provincial in India from Otongwe, distinguishes between the circumcised Botonga and the uncircumcised Mocaranga, both living in what was lately known as Gazaland or Gungunhama's country (Sabi River basin).

We just now referred to Mafumo's territory.

"On the north of English River is the country of Mafoomo. The Mafoomo, or Ofoomo, as Diogo do Couto has it, is situated between the mouths of King George and English Rivers, and it is a very small state."*

In 1589 the Mpfumo or Mafumo tribe which also speaks a Ronga dialect, was known to the Portuguese as the most powerful between the Limpopo and Umbelosi. Their chief Mpfumo probably owed his title to the name Terra dos Fumos, or Smokeland, given to the territory because of the quantity of smoke the Portuguese saw on the land *at night*. So says Do Couto; but one would have thought smoke more easily seen by day! This tribe was also known as the "Makommates," and either gave their name to or received it from the Komati River.

This tribe is supposed to have come from the south-west or through Swaziland, but with this exception all the tribes above mentioned, exclusive of Moamba, who were not Tonga (*viz.*, the Baloyi, the Tembe, Ma-Puta (Ma-Nisa), etc.), were, according to M. Junod, of northern origin, and allied to the Ba-Nyai or Ma-Kalanga. They speak closely related dialects of Si-Nwalungo, and are quite distinct from the shore-tribes in the vicinity of Inhambane, the Tchopi and the Tsonga.

The other tribes included in the Tekeza, Tonga or Nyambane language group which have settled in Portuguese South-east Africa need only be briefly referred to, as they are not mentioned in the "Narrative." Such are the Hlabi and Bila of the great plain of the Lower Limpopo, who speak the Bila dialect; such, also, a tribe from the south-west, and now located between the Komati and Olifant Rivers, known as the Khosa,† which

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* "Narrative" and Owen's Report.

† Needless to say, these Khosa have no connection with the Xosa Kaffirs, spelt Khosas and Koussas by the earlier writers.

speaks the Jonga dialect. In 1778-81 one of the Khosa chiefs, called by the Portuguese the "Grand Caxa," was rich in slaves, and carried on a brisk trade with the Austrians at Delagoa Bay in ivory and copper, and in gold, which was brought to the coast from the kingdom of Kiteve or Quiteve. The copper they obtained by means of the Hlangenu, a Tonga tribe which, so far back as tradition reaches, have dwelt in the Lebombo. The Hlangenu (Ama-Hlangana) speak a distinct dialect, and are probably related to the tribe of A-Thonga now living in Nyassaland; the Hlangenu of the Lebombo trade, as just stated, with the copper-working tribes of the Transvaal, with the Ma-Kalanga and with the Barolong residing so far west as the Kalahari. The Hlangenu are called by the Ba-Venda 'Ma-Gwamba (Sesuto 'Ma-Kwaba), or the people of Gwamba, their first ancestor, by whom they swear. From a curious custom of tattooing the forehead they were called by the Boers "Knobneusen." It was this tribe, probably, that Vasco da Gama met on the Rio do Cobre (Limpopo) in 1489 engaged in their copper traffic, and called by him the Boa Gente.

The Ama-Tonga (to distinguish from the Ba-Tonga) tribes differ from the Zulu-Xosa and Bechuana groups in many ways. They are sylvan and agricultural rather than pastoral, as is evidenced by their currency (employed in the purchase of wives), consisting of hoes instead of cattle. Their ancestral chiefs they bury in forest glades which are sacred to their tutelary spirits. They are devoted to the practive of divination and casting of lots. Their political unit seems to be the village rather than the tribe and, their law of inheritance and succession is exceedingly peculiar.

In the manufacture of weapons and utensils they show much originality, their battle-axes, for instance, being of a type quite different from the Bechuana pattern. Captain Owen, in his report, says of these people that

"they are armed with hassegays, spears and sometimes with small shields;"

but he says nothing of battle-axes. He states, further that they

"have no clothes but the cotton they receive in barter from the Portuguese or woollens they receive from the whalers;"

but in earlier days their scanty covering was restricted to girdles of palm-leaves and aprons of wild-cat skin.

"On the other hand [says Owen], the Vatwahs clothe themselves in skins of animals, live much on animal food, and cover their bodies in war with immense shields of bullock's hide of an oval form much as the Kaffirs on the borders of the Colony. Within the shield they carry from three to six or more hassegays and a spear ready to be taken thence as from a quiver when required . . .

"The natives of Delagoa Bay [he continues] are too timid to undertake anything by night. The Vatwahs always make their attack at night, when they are sure to find no resistance. The latter have an openness of character which speaks much for them; it is said that they never attack their enemies without first sending to inform them of their intention and the time."

This appears rather inconsistent with the statement just preceding, but, according to both Shepstone and Alberti, seems to have been actually the case, in the days before Tshaka, among the Zulu as well as the Xosa tribes.* Yet, as Captain Owen points out, the Vatwah "attacked our tents without notice and most treacherously," excusing themselves by saying that they had been persuaded by a son of King Kapell.

The report continues:—

"The huts of all the natives of Delagoa Bay are circular, well and neatly constructed, small and with a palisade fence enclosing an area round two or more of them."

a description still answering to the Baronga, as described by Junod.

"Polygamy is universal. A man's wealth and consequence is known only by the number of women; they are slaves to the men and the only cultivators of the ground. Yet the men are much disposed to be industrious . . . They are keen traders covetous but honest. Death is the punishment awarded for theft among themselves."

To turn to the "Narrative":—

"The chiefs of Mapoota and Tembe wear their heads shaved, except a large tuft on the crown, on which is placed a small pad or roll into which the wool, after being combed out straight, is tucked in with much neatness. The Zoolos or Vatwahs, on the contrary, shave the crown and leave a ring of wool round the head, but similarly dressed by being turned over a pad and kept in its place by wooden skewers."

II. Zulu.

This reference to the Zulu headring would in itself be sufficient to identify this "very warlike and admirable race of Kaffers," called indifferently Olontotes, Orontotes, Hollontontes, Vatwah, Zoolo and Zoolah, to which we shall now turn our attention.

The word Vatwah, notwithstanding its application as just recorded, appears to have been originally bestowed upon any marauding or warlike tribe of Bantu by one or more of the Ama-Tonga tribes. The epithet "mountains of the Vatwah" given by the coast tribes to the Lebombo indicates that a tribe called Vatwah originally came from the Transvaal or Swaziland plateau.

Captain Owen uses the name Vatwah as synonymous with Zoolo, and in his Report by the use of brackets hints that it is equivalent to "Batua" or "Butua," a term by which the Portuguese of the sixteenth century designated a tribe or district occupied by a tribe which Mr. R. N. Hall locates in the Shangani and Guai basins just north of Bulawayo.

In the sixteenth century, however, Butua was subject to Monomotapa, and was probably inhabited by Ma-Kalanga, or some closely connected tribe, and also, it is possible, by Bushmen. If we accept the nomenclature of the Zulus themselves, "Butua" may be translated as "Bushmanland," for Aba-Twa is the Zulu word for Bushmen. Not only so, we find "Batua," "Batwa," the term applied in many Bantu dialects to the pygmies of Central Africa, replaced in some cases by the allied forms, "Ba-Koa," "A-Koa," "Ba-Roa."

* For Sir Theophilus Shepstone, see Bird's "Annals of Natal," vol. i, p. 156; for Louis Alberti, "Description physique et historique des Cafres," p. 190.

The truth is, perhaps, that the territory of Butua was at one time the home of the pygmies or the refuge of fugitive Bushmen (one and the same race), and gave its name Batwa or Vatwah to the broken and disorganised Bantu tribes who afterwards made their way south from the interior, and thus became attached by the Ama-Tonga to a portion of these tribes upon their invasion returning from the South in 1820. It may be noted that, at that period when Nathaniel Isaacs was in Natal, the term "Botwas" was restricted to the native (Zulu) elephant-hunters. These Botuas may have been a distinct clan once renowned for its skill and prowess like the Aba-Tetwa, but now their sole occupation was elephant-hunting. Under their chief Fodo or Dumesa they had no fixed settlement, but moved about in search of the elephant. When they found a herd of these animals and succeeded in killing some of them they erected temporary huts, and remained until they had consumed all the flesh and secured the teeth, for the purpose of disposing of which they would find their way to the frontier tribes, where they would find a sale for their ivory.*

Butua is, in Si-Ronga, still used as a name for the Zulu country.

Captain Owen states that the "people" of Delagoa Bay also called the Zulus "Hollontontes." It is presumed that he refers to the *white* people residing there. If so, he is probably right in his supposition that the name was "doubtless a corruption from 'Hottentot'" as the Zulus came from the south, which is considered the Hottentot country. But this only shows to what guesswork the blunders of ignorance may reduce all speculations of this kind.

"This name [he adds] they must have been acquainted with when the Dutch first settled in English River, about one hundred and twenty years back; [*i.e.*, in 1720 A.D.] This tribe [*i.e.*, the Zulu] does not appear to have long possessed power dangerous to their neighbours, but some years ago subjugated Mapoota."

We are, of course, now well acquainted with the early history of the Zulu tribe, and know how it grew up from the Mtetwa clan under Dingiswayo, and entered on its career of bloodshed and conquest under Tshaka—the "Chaqua" of Owen and the Portuguese settlers at Matoll. Henry Fynn gives a full account of this in his posthumous papers published in Bird's "Annals of Natal." It is noticeable that in this account he never makes use of the term "Hollentont," although in an earlier description of Delagoa Bay, included by Dr. Theal in the "Records of South-Eastern Africa,"† written apparently about 1823, he refers to "Chaqua, King of the Orentonts." Lieutenant Farewell, at about the same date, gave Captain Owen a sketch of "Chaka, King of Natal and of the Hollentontes." Of this tribe he says:—

"These, among the Africans are the bravest of warriors, being fearless of death, at least when inflicted by the assegai; but they have much dread of fire-arms."

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* Isaacs, vol. ii 42.

† Vol. ii, p. 479.

But in 1824, in his letter to Lord Charles Somerset enclosing a copy of a grant or sale to him of

"Bubolongo or the Port and Harbour of Natal, together with the islands therein and surrounding country as far inland as the nation Gowaqnewkos,"

Farewell speaks of Chaka uniformly as "King of the Zulus," and never once uses the term "Hollentont."

If we are to read for "Gowaqnewkos," "Gonaquas," then if Chaka was not King of the Hottentots, he at all events claimed sovereignty over all the intermediate territory occupied by Xosas, Tembus, Pondos, etc.

Captain Owen, in his report already quoted, gives the following information concerning the redoubtable Zulu tribe:—

"Of the Vatwahs all we learn is that they are from the interior countries at and beyond the source of the Mapoota in the south-west and the mountain west of English River. They are a martial people of free air, noble carriage, being marked by boring the lower pendant flaps of the ears, with very large holes, which is done by no other tribe round Delagoa Bay."

From what follows we find these remarks refer specially to the branch of Abambo or Zulu known as the Endwandwe, who were located between the Nkandhla forest and the present magistracy of Ndwandwe on the sources of the Black and White Umvolosi, and who alone, according to Fynn, were never, while under their chief Zwide, subdued by the Zulu king.

But we find in the "Narrative" that

"Chaka expelled his [Zwide's] uncle Soon Kundava [in the text erroneously printed 'Loon Kundava'] and upwards of five thousand of his adherents; who, passing through Mapoota, Temby and Matoll, laid the whole country waste, even threatening to destroy the Portuguese factory. The extraordinary part of this is that the Portuguese claim the whole of this country, and yet trade with its enemy the Zoolos."

In his report of May, 1823 (already cited), Owen mentions this Soongundava (as his name is here spelt) as being (also?) the uncle of the present king Zeite (Zwide) of the Vatwahs (Endwandwe), a minor at his father's death. Sogundaba, as his name is perhaps more correctly spelt,

"took the government until his nephew should come of age, but then, being unwilling to resign, a war ensued and Zeite turned his uncle and all his adherents out of the country to find another for themselves; for two years these latter have been more destructive than a swarm of locusts to all the countries between their own and the sea, and being of a more manly, bold race than the natives of those countries, have entered every part as conquerors, and at length fixed themselves at Mamalong and Manyess, about thirty miles from the Portuguese factory."

King Zwide, after the succession of Sogundaba, did not long live to claim his title *invictus*. Already weakened by the secession of his bravest lieuteannt, Umsiligazi (Moselekatse) he suffered a severe defeat from Tshaka in the Nkandhle forest. After Zwide's death Fynn and Isaacs witnessed the rout and flight of his successor Sikonyana and the scattering of his forces. The fugitive chief took refuge, accompanied by the greater part of his tribe, with Umsiligazi and his Matebele, as they were now known. The remainder was absorbed in the Zulu forces.

Meanwhile Sogundaba's warriors to the number of several hundreds, were not long in coming into contact with Captain Owen's survey party. They were led by a young chief called

Chinganganv, but were driven off with loss, and later on were warned that in view of their treacherous conduct they would be treated as foes. Thus they were to send in hostages as a pledge of peaceable behaviour or leave the Matoll in four days. But they found discretion the better part of valour, their flight being accelerated, according to the "Narrative," by the sound of a Red Indian war-whoop set up by Lieutenant Vidal.

The Portuguese made some half-hearted attemtps to dislodge them from the banks of the King George River, where they had settled, and ultimately they resumed their course northward. A few months later Captain Owen found at Inhambane

"our old friends the Zoolos under the name of Vatwah, well known as a marauding banditti, leading a life of constant warfare with those around."

M. Junod tells us from Tonga sources that Sogundaba entered into an alliance with Manukosi, alias Soshongana, chief of the Umdwandise (an Abambo tribe), who had fled from his kraals north of the San Lucia Lake to escape Dingiswayo. These two worthies, Sogundaba and Manukosi or Soshongana, continued their march of rapine and destruction along the Lebombo and Langwe foot-hills, fought the tribe of Khosa (the Grand Caxa), and then turned towards the "Bilene," and defeated one of Tshaka's generals, Ngaba or Ngabu, who had been sent in pursuit. They penetrated the regions beyond the Zambesi as far north as the Yao villages. Here Sogundaba quarrelled with Manukosi, and the latter, returning south, occupied the mountains of "Mosapa," hence known as Gazaland, from "Aba-Gaza," as the Umdwandise then called themselves. Manukosi, who died in 1858, had two sons, Mzila or Umsila and Mawewe, son of the great wife and true heir. An incessant feud subsisted between the brothers with varying fortune, first one then the other occupying Gazaland. Ultimately Mawewe died in Swaziland, and Umsila at Mosapa succeeded by his son Gungunhama (Ngungunyane).*

The story of the Endwandwe, according to Miss Alice Werner, is that under "Zangendaba" (Sogundaba) they went first to the Tonga Country, as above mentioned, then to the Basuto or Bapedi in Eastern Transvaal, then to the Ma-Kalanga, where, as already stated, they were overtaken by Ngabu. Here the account from Ngoni sources differs from that given by Tonga narrators. So far from Ngabu being defeated, he vanquished the Endwandwe in two battles and chased them over the Zambesi. Lo Bengula told Selous that there was a great battle which lasted three days; this he had heard from the old men of the Aba-Gaza. Defeated and dispersed, the Endwandwe or A-Ngoni, as they were henceforth called, retreated northward, crossed the Zambesi at Zumbo, and reached the high plateau west of Lake Nyassa, where a branch of this tribe still are recognised as a ruling tribe or caste.

* See also Transvaal Native affairs Department Blue Book, "A Short History of Native Tribes of the Transvaal," 1905.

They were not very clearly distinguished from the Umdwandise of Manukosi, who were also called A-Ngoni or Ba-Ngoni. This tribe is, however, better known as Ma-Shongana or "Children of Soshongana," *i.e.*, Manukosi—hence "Shangaans."

There seems altogether to have been much confusion in this nomenclature of the various tribes. The Ma-Shongana or Mtsyangana of Manukosi and the Hlangenu or Ma-Hlangana (also known as Ma-Gwamba and Knobnoses) are often both called Shangaans.

The Endwandwe were known to Arbousset under the name of "Atoantoas" ("Antwantwa," Sechuana pronunciation), who in the time of Dingaan, "when they were under Mawewe the son of Manukosi" (*i.e.*, when Manukosi and Sogundaba were in alliance), spoke a dialect related to the Zulu, but sufficiently different to render themselves ridiculed at the Great Place at Umvoti as "Maguelega" or stutterers.

III. Landeens.

On the mainland opposite the Bazaruta Islands—*i.e.*, about fifteen miles south of the Sabi River—Captain Owen met some 'Lindeens" or "Landeens,"

"a new nation from the interior who had completely exterminated all the old inhabitants of the sea-coast between Sofala and Inhambane, whose habits were so savage that unarmed traders of the Portuguese seldom visited them. The name of the old chief was Na Ma'ssengoe, and the language a mixture of Delagoa, Inhambane and Majowjie"

The "Majowjie" (A-Jawa or Wa-Yao) and the "Makwanos" (Ma-Kua) were the two tribes round Mozambique best known to the Portuguese in those days when the Zulus had not reached the Zambesi, and Umsila and Gungunyama had not yet established themselves in Gazaland. It is quite clear, however, that the Landeens were neither Ajawa nor Makua; although there is some question as to what tribe the term "Landeen" was originally applied. M. Junod in his "Grammaire Ronga," states that

"the anonymous author of the description of the Bay of Lourenço Marques has pointed out that 'All negroes are Landins!' But [he adds] we can scarcely follow him implicitly in his ethnographical determinations, for he adds 'all the inhabitants of these countries are Hottentots and have no religion'—two affirmations which are quite erroneous."

But this unknown authority is to some extent borne out in the former assertion by the fact that (as we have already seen) the term "Orentonts" or "Hollontontes" was given to the Zulus, probably because they were supposed to have come from the Hottentot country; and doubtless the term "Landin" was extended to the Tonga tribes after the time of Captain Owen's visit to the Sabi in the same loose way. M. Junod continues:—

"The term 'Landin' was applied to the language spoken by the (Tonga ?) tribe by the notary Rosario in a document dated 2nd April, 1805."

To this we may add that in the Statement of Case submitted by the Portuguese Government to the Delagoa Bay Arbitration

Court, we find also that Mayete Kapell is cited as styling himself and his people as "Landins."*

"Actually [proceeds M. Junod], it seems that the Portuguese geographers designated under this name the Tonga tribe to the exclusion of all others."

And he quotes in support M. C. Xavier's map in the Bulletin de la Société de Géographie de Lisbonne:—

"The epithet 'landin' is applied to all the Tonga clans except the Hlengu and Maputa."

"Whence comes this term? [asks M. Junod.] In spite of our researches, we have not been able to discover the origin. It has not been borrowed from the natives, and appears to have originally meant *native* or *black*. The Ronga around Lourenço Marques still employ it in this general sense. they apply it to all natives without distinction."

A similar idea appears also to have occurred to Captain Owen, who adopted the view that it is a corruption of "L'Indien" ("Indian"), only to reject it on second and better thoughts.

M. Junod concludes:—

"It is said that the natives on the Zambesi delta are also called 'Landins' by the Portuguese. It is difficult to adopt this term, therefore, the more so since it is totally unknown in the interior, being scarcely known except in the neighbourhood of the town."

One naturally feels some hesitation in atacking a problem which so great an authority as M. Junod finds a difficult one; yet the answer to the question: "D'ou vient ce terme?" does not seem far to seek.

Like the word "Hollentont," the term "Landin' 'has probably been loosely, carelessly and erroneously applied to all the Tonga tribes, and even to all the East Coast Bantu, Abambo, etc., not excepting the Zulu; but at an earlier date these tribes, as well as the southern Tonga, such as the Hlengwe (Hlengu) and Maputa, were not called Landeen—*i.e.*, the name was restricted to the Ama-Tonga north of Delagoa Bay, especially to the Ma-Gwamba and Ama-Hlangenu or Ama-Hlangana, and at an even earlier date was confined to the inhabitants of the Sabi basin and the Zambesi delta. But these tribes, as M. Junod himself has shown, probably descended from the Ba-Loyi or Ba-Rotse and the Ba-Lunda or Ba-Londa, who in Livingstone's time lived in the country "named Londa, Londa or Lui by the Portuguese,"† now the kingdom of Lewanika, and who on reaching the coast would be the "new nation from the interior" referred to by Owen. According to Coillard, the Barotse themselves say they came from the East, and claim kinship with the Ba-Nyai.‡ However this may be, if we grant that the northern Ama-Tonga had a mixture of Londa blood or bore the Londa name and held its traditions, then they would naturally be called by the Portuguese of the early nineteenth century "Londinos" or "Landinos," just in the same way that the Ba-Bihe or car-

* "Records of South-East Africa" vol. ix, p. 135.
† "Missionary Travels," page 306.
‡ "Threshold of Central Africa," page 234.

rier-tribe of Angola are called "Bihenos," and the Ma-Kua of Mozambique and Nyassaland are called "Makwanos."

The theory that the Landeens had their origin in Ulunda is strengthened by other instances of Central African tribes finding their way to the south-east coast. Thus we have the filtering down of the Makaranga and other tribes into Natal; the evidence adduced by the identity of name and traditions of the Baloyi of the Limpopo and of Lealuyi; the case of the Batonga of the sixteenth century, of which a portion resided in the Middle Zambesi, where they still exist, better known under the Sechuana form of the name Batoka, and a portion lived on the Lower Zambesi south of Sena, since destroyed as a separate tribe by the Portuguese. Finally we have the evidence of Major A. St. H. Gibbon, who points out that his Zambesi boys could converse with the Malunda, while the intermediate languages spoken between this country and their homes were quite foreign to them.

"This seems to point to the fact that two sections of the same tribe have at one time been separated either by the emigration of one of them, or by the wedgelike insertion of a great migratory move driving them right and left."*

METEOROLOGICAL PHOTOGRAPHS.—The United States Weather Bureau is forming, in its library at Washington, a collection of meteorological photographs, and the Chief of the Bureau has requested that this intention may be notified to members of the South African Association, whose contributions to the collection will be gladly welcomed. The following will be specially acceptable: Views of meteorological offices, observatories, and stations: Pictures of meteorological apparatus; Portraits of meteorologists; Views of their birthplaces and homes; Views showing the effects of storms, inundations, frosts, heavy snowfalls, etc.; Cloud photographs: Photographs of optical phenomena, such as rainbows, haloes, mirages, Brocken spectres, etc.; Photographs of lightning and its effects; Photographs of meteorologically interesting pictures in old books, or of early prints and paintings, such as contemporary pictures of the damage wrought by the Great Storm in England in 1703. Members who may be willing to present such pictures to the Weather Bureau, or to exchange them for Weather Bureau publications, are requested to address their communications to the Chief of the United States Weather Bureau (Library), Washington, D.C. Senders are asked to note on the back of each print as much pertinent information as practicable, and on direct views of meteorological phenomena the place, date, and hour at which each view was taken should be noted, as well as the direction toward which the camera was pointed.

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* "Africa from South to North," vol. ii, p. 36.

TWENTY-FIVE YEARS OF CHEMICAL INVESTIGATION IN THE CAPE COLONY.

By Charles Frederick Juritz, M.A., D.Sc., F.I.C.

Some people, seeing the title of this paper, may possibly enquire with surprise whether there *has* been any chemical investigation at all in South Africa during past years. After a long time spent in pursuing the purely practical, it almost seems as if the pendulum is now swinging to the other side, and on all hands a cry is arising for more research and more investigation. Do we, when making such demands, always understand what we mean? Are the expressions that rise to our lips not often merely catch-words? Is the return of the pendulum a reality, or is it merely an illusion? Or is the illusion ours when we—the workers of the past—imagine that there has been *some* value in the work that has occupied our minds and hands these last twenty years? Have we—as a people—really ceased to concentrate all our thoughts on the purely practical, or is this cry for research after all nothing more than the seeking for some short-cut to "practical" results? If the latter be the case—and I fear that too often it is—then we are really no wiser now than when we took no account whatever of research or investigation. If, then, we are under a delusion, it is time that we take thought, lest, awakening to a dawning sensation that we have not been going along right lines in the past, we may unconsciously head off in a different direction, imagining that *now*, at all events, we are on the right course. This, I think, is the serious danger that faces us at present.

As much as anyone, and perhaps more than most, the writer has, during the last quarter century, repeatedly urged the need of chemical investigation, and contrasted research and investigation with the short-sighted policy that finds no value in anything that is not immediately practical. In the present tendency, however, I cannot discover any inclination to recognise that the path of unfettered research is in the end surest and safest; the "practical" is still the fetish which we adore, and while we surrender ourselves to the guidance of a pseudo-investigation, we do so only because we have a vague fancy that we will thus be carried to our "practical" goal by the speediest way. Even then we like to retain sufficient control to afford ourselves the liberty of using the goad should the pace not be swift enough to please us.

That, to my mind, is far from the ideal that underlies investigation. If there is to be any surrender to the leading of research, it must be unconditioned.

Furthermore, to direct a scientist that he must go and make a discovery in a certain direction, and to demand from him, at the end of a specified period, why the discovery is not forthcoming, may be an indication that one's ideas of the methods and possibilities of science do not even attain to the level of those of the Shah who wished King Edward to execute the

Astronomer Royal because he had no solar eclipse handy at the time when His Oriental Majesty happened to visit the Observatory. We cannot make scientific discoveries to order, and, if we appoint individuals or establish institutions with such an object in view, our hopes are doomed to extinction. The only way to proceed is to subject Nature to cross-examination by experiment and counter-experiment. Thus, and thus alone, shall we be able to elicit anything of value. How these questions are to be put to Nature is a matter best left to counsel, and if the client interferes with, or limits his adviser's discretion in this respect, he risks losing his case and the costs as well. Most scientific discoveries—I am speaking now of those with an obvious practical bearing—are made, as it were, by accident: the investigator pursues the even tenor of his way, and in the course of his journey the discoveries, one might almost say, just happen. The last expression does not exactly fit, for the scientific mind must be on the *qui vive* for such "happenings," but my point is that they come along the level of the pathway, and are not just swooped down upon as the prey is by the eagle.

When in the past I have lamented the lack of chemical investigation, it has not been with the idea, which some seem to have to-day, that eagle-flights ought of necessity to replace the steady pursuit of a terrestrial pathway if we are to make satisfactory progress. My complaint has rather been that the path has been hemmed in and fenced, that barbed wires and obstacles of other kinds have hindered advance. We shall be making a sad mistake if we think that the proper way to pursue henceforward is to leave all the tangle and obstruction where it is and to betake ourselves to wings. Our failure will then be sorrier than ever before.

We read in history that when the Israelites emerged triumphant from the shackles of Egypt, a "mixed multitude" at once exhibited parasitic tendencies toward the freed tribes: but it was not long ere those unrestrained camp-followers proved a thorn in the side of the new nation on its way to the Land of Promise. If we have indeed shaken off the ultra-utilitarian fetters by which we have hitherto been bound, our path through the wilderness will be anything but pleasurable unless the eggings on of those who are *with* us but not *of* us can be restrained. As Professor Meldola said in his Presidential Address to the Chemical Society (London) four years ago*, it is "the steady plodding work which culminates in great discoveries."

Now I am happy to say that during the last quarter of a century there has been done, under exceedingly narrowing circumstances, a relatively large amount of just this "steady plodding work" in my own particular science, and for the most part it has also been, as Professor Meldola went on to say, "quite unheeded by the general public." As for the institution over which I have the privilege of presiding during twenty years, the Cape Government Laboratories, I have freely admitted that

* "Trans. Chem. Soc.," vol. xci, p. 628.

I have not been at all satisfied; and so others, taking their cue from my unconcealed dissatisfaction, have straightway raced ahead and said in effect: "Yes, we have done too little research; let us push on and get to some practical results." Precisely; that is just where the fault lies. We are striving to approach our problems from the standpoint of the *art* rather than from that of the *science*. The old, exclusively utilitarian tendency is still there, as strong as ever, but unless we are careful it is merely going to masquerade in a dress labelled "Research"—a dress showily ornamented so as to strike the popular eye, very different in aspect from the sober hues by which true research is characterised.

In view, then of the false position that is being thus created, and the misleading issues that have been raised, it is my intention, on this occasion, briefly to review some of the plodding work that has been accomplished, step by step, along the line of chemical investigation in the Cape Province. Before passing on to this phase of my paper more definitely, let me emphasise the fact that scientific investigation is of necessity always plodding, whether, like Professor Hertz, we attempt to deflect electromagnetic waves by means of zinc sheets and so all unconsciously pave the way for the wireless telegraphy of to-day, or whether, in a country where nothing of the kind has ever been done before, we do the despised, humdrum, and, as some call it, routine work of chemically analysing one sample of water after another, until afterwards, when we have thus accumulated many thousands of such analyses from different localities and sources, we collate our figures and find ourselves face to face with numbers of interesting, important, and it may be even far-reaching—yes, let me add that word—*practical* conclusions. In this time of national organisation in South Africa I would say with all deliberation, if we want *real* chemical investigation, and not a *sham* that will merely catch the eye of the populace and tickle the popular imagination, there is no branch of chemical science that we can afford to ignore. We should recognise the cohesion that exists, and the solidarity, so to speak, of the whole chemical body, in which the eye cannot do without the hand, nor the hand without the foot.

And now I shall pass on. To begin with, let me just give some figures to show the extent of the work that has been done in the Cape Laboratories from 1891, when they were placed under my charge, up to the close of 1910. The total number of articles that were chemically analysed during that period is 37,982. Of these, 11,324 were milk, 1,820 were water, 1,849 were brandy, 1,573 wine, 1,146 soils, 1,347 vinegar, 883 were rocks assayed for gold, 852 were samples of butter, 507 were fertilisers, 267 were sheep and cattle dips, 331 were coal; there were 159 cases of poisoning investigated; 114 specimens of sulphur imported for the treatment of oidium in vines and for sheep-dips were examined, and 91 samples of common salt, the produce of the Union. In addition to these, 15,719 other articles were subjected to chemical analysis, into the details of which it is impossible to enter here. A few of these latter may be referred to more particularly later on. All branches of the Public Service were aided and all classes of the community.

Water.

The water samples analysed—they number, it will be seen, close on 2,000—afford an instance not only of the value of laboriously adding analysis to analysis, in the plodding way that has already been spoken of, but also of the manner in which the results of analyses of isolated samples, which come to the Government Laboratories from quite extraneous sources, ultimately become, by careful conservation and methodical collation, aggregated into an investigation of the greatest practical worth. The *direct* objects of these water analyses have been for the most part to ascertain the suitability of the water either for potable purposes or for use in engine boilers. Of mineral or irrigation waters there have been comparatively few. As to their localities, these waters were procured from places distributed all over the Cape Province, and as to their respective sources, they may be divided into three classes: surface waters, subsoil waters, and deep-seated waters. The results of these many water analyses are card-indexed in the Cape Town Laboratory, and the bulk of them still await the requisite leisure for compilation, comparison, and interpretation, and then codification of the facts revealed. With the records of the potable waters there has hitherto been no opportunity of dealing, and of the boiler waters the indexed results of analyses of the surface and subsoil waters also remain unsystematised. To the figures given by the deep-seated waters alone had there been sufficient leisure to attend, and the inferences which they enabled me to draw were published in my Presidential Address to the Cape Chemical Society in 1908. Of the waters belonging to this class somewhat over 350 had been analysed, and comparing the localities whence these were procured with their apparent depth of origin, and so with the geological formation whence they took their rise, the following general conclusions were arrived at:—

1. That the purest deep waters in the Cape Province are those of the Table Mountain and Stormberg series.
2. That lime and magnesia compounds are far more abundant in the waters of the Karroo system than in those of the older rocks, the Bokkeveld series apparently excepted.
3. That the Stormberg and more recent Karroo rocks, namely, those of the Burghersdorp series, yield waters containing considerably smaller proportions of chlorides than those of the older Karroo deposits.
4. That the most saline waters appear to be those of the Uitenhage, Dwyka, and Bokkeveld formations.
5. That from the waters of the Table Mountain series sodium carbonate and sulphate are absent, and also, as a rule, magnesium carbonate; but that calcium sulphate, on the other hand, is generally present, as well as magnesium sulphate and chloride.
6. That the waters of the Malmesbury beds differ from those of the Table Mountain series in containing a larger all-round proportion of salts and in the more frequent presence of magnesium carbonate, and consequent absence of calcium sulphate.

7. In none of the Ecca waters has any calcium sulphate been found, magnesium carbonate being invariably present, and in most cases also sodium sulphate, often with sodium carbonate.

8. That the older Karroo rocks yield waters of more varied composition, calcium sulphate again making its appearance, and even, in some instances, noticeable amounts of calcium chloride.

9. That the Middle Beaufort beds, on the other hand, show much more uniformly constituted waters. Calcium salts other than the carbonate are absent, and magnesium sulphate and chloride rare; sodium salts bulk more largely in proportion, but, relatively speaking, the amount of chlorine is less.

10. That this condition is more accentuated in the Upper Beaufort and Stormberg waters, the proportion of chlorine appearing to diminish as one passes geologically upwards from the Lower Beaufort to the Stormberg formation.

11. That the majority of waters of the Middle and Upper Beaufort and Stormberg series contain sodium carbonate, black alkali, in solution—an important fact in connection with agricultural operations in those districts.

Looked at from the engineer's point of view, the waters from the Table Mountain series were, without exception, very good; those from the Malmesbury beds were fair on the average; those from the Bokkeveld series either poor or very bad. The Dwyka waters proved to be, generally speaking, very bad. The Ecca waters were rather poor, those of the Lower Beaufort beds were bad as a general rule, while those of the Middle Beaufort beds were good. The Burghersdorp or Upper Beaufort beds supplied water of fair quality, and good water was obtainable from the Stormberg series. The Uitenhage series gave waters of very variable quality; most of them, however, were very bad.

In this connection I may be allowed to repeat just one sentence of the address to the Cape Chemical Society in which the above summarised results were first detailed. That sentence bears closely upon some of the opinions animadverted on at an earlier stage of the present paper. Speaking of the numerous water analyses which, when collated, afforded the opportunity of drawing the above conclusions, I said:—

"We have a number of isolated facts, but we have to connect them up by piling observation on observation, analysis on analysis, fact on fact; and this not at haphazard, but systematically, carefully recording all modifying or influencing circumstances; and we need, too, to educate the public mind with regard to the value and desirability of agricultural chemical investigation."

Toxicology.

But I must pass on to another exemplification of exactly this point which the work of the Cape Laboratories has afforded. In the short statistical summary of our work above given it was said that 159 poisoning cases had been investigated. Some of these proved to be nugatory, in others arsenic had been the poison administered, in others again strychnine, or some other of the poisons more or less frequently met with in toxicological practice. In very many of the cases, however, the problem set the analyst was of quite a different order. In the London courts recently the skill of the analyst who detected a small quantity of the obscure and *rare* poison hyoscin was deservedly the subject of high admiration. But many a case is tried in the Eastern Districts Circuit Courts of the Cape Province wherein conviction turns on the presence or absence of poisons *wholly* unknown to English scientists. Almost every year, for many years past, I have publicly recommended that steps be taken to investigate these unknown poisons, and up to the present practically all that we know of their chemical nature has been brought to light through the medium of the Cape laboratories. I am not unmindful of the work that has quite lately been done at the Wellcome Research Laboratories, but it is scarcely to the credit of South Africa that it should contentedly leave the active principles of its therapeutically valuable indigenous flora to be exploited by private institutions in other parts of the world. The more desirable course is that enough leisure should be at the disposal of those who have already initiated the local investigations, in order that they may thereby be enabled to carry them to the important issues that undoubtedly await them. *That* would be true research, and if by research we mean something that will issue in striking results, it is not impossible that it may possess even that merit. Six years ago, in a paper read by me before the South African Philosophical Society,* I summarised the work that had been done in this direction in the laboratories under my charge; and since then further investigations of similar nature have been set in motion. In no case, however, has there been any opportunity of pushing any one of these investigations to anything like finality, and I shall greatly regret it if, through faulty perspective, those who have directly imparted the primary impulse to several trains of investigation are now debarred the right that priority gives them of continuing their researches. The work that has been done in our laboratories clearly demonstrates that there are immense possibilities before the chemical investigation of the active principles contained in South African plants. These are not limited to the aloes and buchus, but in many other genera and species of the country's flora there are alkaloids and glucosides, oils, resins and compounds of the aromatic series in profusion merely awaiting discovery and practical application—and let me here again say the knowledge we possess on this subject has come to us in the shape of that much-despised "routine" work. None the less it has, as we shall see, greatly assisted us in indicating just what special subjects were open to fuller investigation; in fact, it has been the only available means towards this end.

Let me briefly give an indication of what we have found thus far. It is just over ninety years since quinine was discovered and isolated: its value as a tonic and febrifuge is so universally known as to be quite independent of special emphasis, and as a prophylactic for persons entering malarial districts it is well-nigh indispensable. We have heard it said that for every disease Nature provides a remedy close at hand, and so, when

* "Trans. S.A. Phil. Soc.," vol. xvi, part 2. pp. 111-133.

the Spanish colonists in Peru were ravaged by intermittent fever, they found an effective drug in the Peruvian bark from which the alkaloid quinine has been prepared in such quantities these last ninety years. Southern Africa, too, has its malarial regions, but in the Transkeian forests flourishes a tree which attains a height of fifty feet, and its bark also is declared to possess therapeutic properties similar to those of the Peruvian cinchona. It is, in fact, locally known as the quinine tree, and by natives as *umjela* (*Tabernæmontana ventricosa* Hochst). From the bark of this large tree—its trunk is about four feet in diameter—needle-shaped crystals were extracted in the Grahamstown laboratory. The alkaloid, as it appears to be, is not quinine, however much it may resemble the latter in its anti-febrile properties, nor is it identifiable with any other of the cinchona alkaloids. Its chemical reactions are very striking, and for an application of its therapeutic value it awaits investigation from the medical side.

Another potent drug is the alkaloid brucine. It may be described at diluted strychnine, and is capable of therapeutic application where less powerful action is desired than strychnine would produce. A similar active principle has been found in the bulb of *Buphane disticha* (*toxicaria*) Herb., which contains about four per cent. of what appears to be an uncrystallisable alkaloid. The plant has undoubtedly proved fatal, and, although Bushmen are said to have used it as an arrow poison, Smith* mentions it as a remedy for the disease called red-water.

From a wooded kloof near Collingham, in the Albany Division, after a four months' search for a plant that was said to have caused the death of a Kafir woman, the Senior Analyst at Grahamstown procured bulbs belonging to the *Hæmanthus* family—whether *puniceus* or *magnificus* could not be definitely settled—from which he succeeded in extracting what appeared to be an alkaloid new to science, in the proportion of about one per cent. of the dried bulb. The usual physiological tests were made, in all cases with fatal results, and it was ultimately proved, by comparing the chemical reactions, that the woman had died after partaking of a plant preparation made from what was in all probability the identical species. In this case the physiological action, although resulting fatally, had not been sufficiently marked in its symptoms to enable the therapeutic possibilities of the plant to be estimated.

So much for plant alkaloids; then, in several cases, what were evidently glucosides have been met with under similar circircumstances. For instances, the plant *Trichilia dregei* E. Mey., which caused the death of a Kafir woman, was investigated, and slender needle-shaped crystals, probably of a glucoside, were obtained from it. Another plant containing a glucoside, uncrystallisable apparently in this case, is *Acocanthera venenata* Don. The glucoside is highly poisonous, arresting the heart in systole, but if its action were under proper control it may possibly serve as a valuable drug somewhat akin to digitalin. A

* "S.A. Materia Medica," 3rd ed., p. 158.

full account of the Cape laboratory investigations in this connection will be found in my "Notes Regarding South African Pharmacology," the paper quoted above as having been communicated to the South African Philosophical Society in 1905.

In addition to alkaloids and glucosides, poisonous glucosidal resins and allied bitter principles have been found in a variety of indigenous plants. For instance, the dried root of *Polygonum tomentosum*, var. *glabrum*, was found to contain two and a half per cent. of an acrid resin possessing characteristic chemical colour reactions, and acting physiologically as a powerful depressant. The plant is made into a decoction by the natives in Tembuland and applied remedially in the cattle disease known as black-gall sickness. As far as could be seen from the few physiological experiments that it was found possible to undertake, the active principle of the plant exerts a paralytic effect on the muscles of the heart, eventually arresting that organ in systole. On mice it proved rapidly fatal, and the probability is that on human beings a sufficient dose would have a similar effect; in fact, it was the death of a native girl at Kingwilliamstown that led to the undertaking of this investigation.

A similar fatality led to an examination of *Hæmanthus natalensis* bulbs. From these bulbs .168 per cent. of a yellowish non-crystallisable substance was extracted, and, after a series of physiological experiments had been made, the conclusion arrived at was that the plant is not directly poisonous, but produces rapid emesis accompanied by violent straining, which, in the case of constitutions not robust enough to withstand the effects, may well prove fatal.

In 1907 a bulb known to the natives as *tyumtyumana*, but which it has hitherto been impossible to identify botanically, was investigated and found to contain a resinous body possessing well-defined and characteristic chemical reactions. The resin was bitter and acid in character, and a woman was proved to have died after partaking of the bulb. Physiological tests on animals abundantly proved its rapidly acting toxic nature. Three years later a herbal decoction prepared by a Kafir doctor came under notice of the laboratory at Grahamstown, and was found to possess a peculiar herbal odour which at once associated it with the *tyumtyumana* of the 1907 investigations. A resinous substance was extracted from it, yielding chemical reactions identical with those then observed, and the effect on the heart and blood—for a person had died after drinking of the decoction—was also similar to that resulting from the administration of the *tyumtyumana*.

A year after the first experiments with the *tyumtyumana* bulbs, an investigation was begun of another bulb, called *usiyagana* by the natives, and no less than nine months were spent unsuccessfully in endeavouring to procure a specimen with leaves and flowering stalk complete for botanical identification. In this case, too, severe physiological experiments showed that severe emesis set in rapidly after administration, terminating fatally, in the case of a dog, within thirty minutes, the heart, after death, being distended and engorged, and the muscular tissue flabby. Further chemical examination of the bulb showed that the active principle was apparently a glucoside and identical with one found in another unidentified bulb from the same district (Tsolo) five years previously.* So violent had been the emetic effect upon a woman, whose death in 1908 resulted in the investigation being taken up, that her spleen was ruptured during the paroxysms.

A plant stated to be a species of *Helichrysum,* but which it was at the time impossible to identify more precisely, was procured from Elliotdale in 1908 for the purpose of investigating its supposed toxic properties. Here again an acrid resinous body was found, and definite chemical properties recorded. A peculiar nauseating odour was evolved on heating with water. Physiologically the active principle of the plant was found to act as a depressant, coupled with emetic and slight purgative properties, without any striking toxic effect. Moreover, there has hitherto been no definite evidence of any human fatality in consequence of administration of the plant in question. Two years later, in the roots and tubers of *Aster hispidus* Bak. (*Diplopappus asper* Less), known by the Bizana natives as *nozixekana* and in Elliotdale as *mtshekisana,* an acrid resinous substance was discovered amounting in the air-dried material to nearly .19 per cent. The plant proved to belong to the same species as that investigated in 1908, and physiological experiments were again made with precisely similar results. The chemical reactions, too, were identical with those of the plant already mentioned.

About the same time last year a plant known to natives as *montuza,* and identified as *Knowltonia bracteata,* was the subject of some investigation. The plant belongs to a genus the species of which are extremely acrid, and the commonest are popular colonial remedies for rheumatism.† A fairly large proportion of a resinous body possessing very characteristic chemical reactions was obtained from this plant, but physiological tests did not produce any apparent effects.

Decoctions prepared from *Bowiea volubilis* Harv. had been found to result fatally in the case of human beings, and some specimens of the plant were accordingly submitted to chemical examination. An acrid substance was extracted, and it proved to act as an irritant poison and a strong emetic. Sufficient of the plant could not be procured to admit of any definite opinion being advanced as to the presence of an alkaloid or a glucoside, but there was no very characteristic chemical reaction observable.

Smith‡ mentions the South African beetle *Mylabris bifasciata* as deserving of export for blistering purposes, and predicts that it will supersede the Spanish *Cantharis vesicatoria* in certain

* See "Notes on S.A. Pharmacology," p. 130.
† Harvey and Sonder, "Flora Capensis," vol. i, p. 4.
‡ "S.A. Materia Medica," p. 230.

markets (provided it can be found in sufficient quantity) for the reason that it contains twice as much cantharidin as the latter. He goes on to observe:—

"This *Mylabris* yields 2.09 per cent. of cantharidin, accompanied with only 10.45 per cent. of extractive, while the Spanish *Cantharis* produces only .42 per cent. (of cantharidin) and the more troublesome amount of 18 per cent. of extractive."

In this connection a rather curious result followed an investigation by Mr. Muller in the Grahamstown laboratory during 1909. An analysis of the *Mylabris* which he made showed even better results than those quoted by Smith, for with practically the same amount of cantharidin—nearly two per cent.—there was only seven per cent. of extractive matter, but the remarkable feature consisted in the fact that the stomach and other viscera of a man, who had obviously been poisoned by an administration of powdered *Mylabris*, contained no trace of cantharidin, although fragments of the insect's wing cases were clearly present.

One incidental remark before another branch of investigation is considered. During the nine years 1902-1910, inclusive of cases of poisoning, the Cape laboratories investigated no less than 259 chemico-legal cases in all. These, looked at superficially, may be truly spoken of as "routine work," and in many cases no new features could be expected, yet they were worth undertaking—from the point of view of scientific progress—because without this branch of work the interesting steps above recorded in connection with the country's plant poisons would never have been taken.

Soils.

Here I pass on to another phase of our investigational work —a phase which I have brought so prominently before the public in various ways during several years past that my words concerning it on this occasion shall—relatively to its importance—be few. I refer to the investigation of the country's agricultural soils. With this class of investigation my official connection with the Cape Government may be said to have begun, for my first report to Government was dated the 30th October, 1886, and it comprised the results of analyses of twenty-nine representative tobacco soils of the Cape Colony from the Divisions of Tulbagh, Ceres, Worcester, Malmesbury, Swellendam, Heidelberg, Riversdale, George and Oudtshoorn. The Government had then no laboratory of its own, and by favour of the South African College Council and Professor Hahn, the investigation was conducted in the chemical laboratory of that institution. Since then, as already stated, over 1,100 soils have been analysed in the Government's own laboratories, and the results of these series of soil investigations have been published by me in the form of a royal 8vo volume of 221 pages. In that volume I reiterated the lamentation to which I had previously given utterance in my pamphlet on "The Underground Waters of the Colony," and in that on "South African Pharmacology," *viz.*, that investigation in each of these three respects had not been ampler and more systematic; but that there had been a far more than merely appreciable amount of investigation everyone who takes the trouble to read these records will, I think, readily concede. Some of the broad results of the investigation relating to our soils were lightly touched upon in the closing pages of the 8vo volume above mentioned; here, therefore, my touch will have to be even lighter. The results there recorded amply show the solid reason for initiating the undertaking. If they do not trace out fully the connection between the ravages of bone disease in stock and the composition of the soil, they at all events call attention to the remarkable fact that these diseases find greatest foothold in just those areas where the soil lacks lime and phosphates, and that the latter are lacking in many places is made quite clear. The general poverty of the sandstone of the Table Mountain and allied series is also evident, and if, basing the question on that fact, it be asked why, then, "lamziekte" does not make its appearance in the south-western districts as well as in the east, one answer starts up at once: In the more easterly districts the rocks in which the plant food constituents are deficient stretch uninterruptedly over vast extents of country, while in the west they are sufficiently diversified by granite and the rocks of the Bokkeveld series. Not the least interesting feature of the soil investigations has been the confirmatory testimony, given in many cases by the practical experience of farmers, of the correctness of the theoretical deductions as to the probable fertility or otherwise of certain soils, made, upon the presumption of certain data, from the chemical results. In my book on the Cape Colony soils specific cases of this agreement are mentioned with respect to farms in the Districts of Beaufort West, Cathcart, Elliot, George, Kimberley, Komgha, Malmesbury, Paarl, Robertson, Steynsburg, Swellendam, Tulbagh, Victoria East and Worcester. Of course, discrepancies do sometimes occur, but in the present state of enquiry one must needs meet with seeming anomalies; there is therefore a plain necessity for pushing investigations further. The best means of determining the proportions of plant food constituents in the soil have, to a certain extent, been locally studied, with the result that methods have been finally adopted which appear suited to the country's circumstances.

It has also been shown, in connection with the irrigation projects that must continue to take up a large place in the future development of agriculture in this country, how essential it is first of all to enquire into the condition of the soil, and here not only the alkali deposits themselves need investigation, but equally so the physical condition of the soil. The value of investigations of this class was very definitely established in connection with the abortive Thebus irrigation project, where they were the direct means of saving the Cape Government from entering into an expenditure of £150,000, that had been voted for the purpose by Parliament.* How frequently barrenness

* *Vide* Senior Analyst's Report, January-June, 1904, pp. 22-30.

may be brought about by factors other than mere deficiency of plant food in the soil the Cape investigations have made abundantly clear, and in many cases where there is no question of barrenness at all the difference of texture between soils suited, let us say, to the cultivation of potatoes and other soils of a more clayey nature has exercised a controlling influence upon the class of farming practised. It has been observed during the course of our investigations that geological influences perform an important part in this connection. For instance, mechanical analyses of the soils taken from the south-western corner of the Cape Province, where the Malmesbury and Table Mountain geological series prevail, show that these soils are, on the whole, coarser than the soil of the area within which, for the most part, the Bokkeveld series occurs; and this, again, yields a soil of coarser texture than the rest of the country from which soils have been examined, and covered chiefly by the rocks of the Karroo system, and more particularly by those of the Beaufort series. Then, again, the soils of the northern part of George and the Division of Uniondale are considerably coarser in texture than the soils south of the great Outeniqua range—that is to say, than those of the southern portion of the Division of George and the Knysna Division. In thirty soils taken south of the Outeniquas the percentage of fine earth—*i.e.*, of particles below ½ mm. diameter—in the soil averaged about 94.5, but in twenty-one soils collected to the north of the mountain range the fine earth averaged only 69.3 per cent. I must confess that we have not had much opportunity of studying the physical texture of the Cape soils; mechanical analyses have, however, been made of soils selected to typify three broad classes, namely, the grain soils of the south-western districts, the fruit and general farm soils of the Worcester-Robertson area, and the deposited silts of the Orange River.

From a chemical point of view the poverty of the Table Mountain and Malmesbury series soils has been shown to contrast with the richness of the soils where the Bokkeveld series and the Karroo system prevail, not to dwell upon the high chemical value of the river silts, the products of the erosion and denudation that are going on elsewhere.

The knowledge which we have gained about our soils is not so exclusively due to the accumulation of routine analyses as in the case of some other phases of our work, for much of the soil work was of my own initiation; but even here it remains true that the collation of individual results constitutes the sum of them an investigation of exceeding value.

Fermented Liquors.

The list given towards the close of my introductory remarks, summarising numerically certain aspects of the Cape laboratories' work, includes 4,769 analyses of brandy, wine, and vinegar. If anyone were to enquire what these analyses have resulted in, he would at once be told that their outcome has been the Wine, Brandy, Whisky and Spirits Act of 1906 and the Wine, Spirits, Beer and Vinegar Act of 1908. How did such a result come about? To answer that question we must go back just over six years. Large quantities of brilliantly coloured so-called fruit cordials were being exposed for sale throughout the country. As to the manner of their manufacture there was very little doubt, and so representative samples were procured and analysed. At first blush the analysis of such synthetic preparations could have but little, if any, interest for the agriculturist, and yet this first step led to a series of investigations culminating in laws possessing the closest bearing on certain branches of agriculture. Those cordials were found to contain varying quantities of the preservative salicylic acid, and, amid the mass of conflicting evidence that the subsequent legal proceedings brought forth, it was soon seen how hopeless it was to rely upon the ordinary machinery of the Food Adulteration Act to restrain the sale of such beverages. However, even gentlemen who gave scientific evidence for the defence readily admitted that the arguments adduced by them in favour of the addition of salicylic acid to the cordials then under consideration could not apply in the case of wines. Steps were taken at once to investigate the point, and ultimately led to a far-reaching series of analyses. Eighteen samples of wine were first of all procured and tested; the only preservatives found in any of them were sulphur dioxide and salicylic acid. Then a fuller investigation was made: 104 samples were procured from farmers and 176 from dealers. No preservatives except salicylic acid and sulphur dioxide were found in any of them, and in none of the farmers' wines was there any salicylic acid. In my report submitted to Parliament,* I strongly urged the need of specific legislation, and especially of legislation embodying definitions and limits in which the Food and Drugs Act of 1890 was lacking. In the same Report† I also drew attention to the *impasse* that followed upon a series of investigations that had been made into the composition of the brandy and whisky on the local market, when a test case against the vendors of a factitious whisky had resulted in a dismissal on account of the absence of a working definition. I was accordingly commissioned to draft a Bill which, with a few modifications, ultimately emerged from the Legislature as the Wine, Brandy, Whisky, and Spirits Act of 1906.

It was generally recognised that this statute was to be only the first of a series, but before a further tightening of the reins could take place it was thought desirable to obtain fuller information as to the composition of Cape brandies, and hence an investigation was instituted in 1906 on lines similar to that adopted for the wines during the previous year. Full analyses were therefore made of thirty-seven samples of Cape and the same number of imported brandies during that year, and of forty-seven imported brandies and whiskies during the subsequent year. These were supplemented by thirty-eight analyses of Cape

* Report of Senior Analyst for 1905, pp. 18-20, 25.
† Pages 15-17.

wines, all the 149 liquors being specially procured for the purposes of this particular investigation. The outcome was that once again I was entrusted with the drafting of a legislative measure, and as, following on our numerous analyses of vinegar, an extraordinary proportion of which had proved to be practically diluted and coloured acetic acid, I had repeatedly drawn attention to the necessity of specific vinegar legislation, it was decided to embody the requisite clauses in the Bill, and so the second Statute of the series became law in 1908. Further legislation along these lines had been under contemplation, but this, as we all know, has been suspended by the establishment of the Union. That the Acts resulting from our investigations have been appreciated is clearly evidenced by the frequently expressed desire, both inside and outside of Parliament, for their speedy extension so as to embrace the entire Union within their scope.

Just here I may say that in 1907 the chemical composition of typical Cape wines of definite origin was investigated, and all the prize wines exhibited at every Government Wine Show during the last score of years have been systematically analysed in the Cape laboratories. These would probably aggregate about six hundred in number, and the results obtained are all available for compilation when time permits.

Let me conclude this section of my paper by once more drawing attention to the fact that the investigations into the composition of Colonial wine, brandy and vinegar on the one hand and of the imported articles on the other were undertaken in the interest of the South African agricultural community, and it was in that interest that the subsequent statutes were passed and are at present being administered; yet it was in proceedings taken under the Food and Drugs Act that all this had its origin. It was this kind of interdependence that I had in view when referring just now to the solidarity of the chemical body—a solidarity that will have to be carefully maintained if the greatest good of the greatest number is to be achieved.

Fertilisers.

The two enactments above mentioned were not the sole representatives of the fruition that came after years of laboratory work. In 1907 a statute was passed by the late Cape Parliament that had its first beginnings fifteen years earlier: this was the Fertilisers, Farm Foods, Seeds and Pest Remedies Act. As long ago as 1892 I suggested that investigation should be commenced of the commercial fertilisers on sale in the country, and this was done in the first instance by purchasing the fertilisers through the medium of a commission agent. Almost at once the discovery was made that some, at least, of the fertilisers on the market exhibited considerable anomalies of composition. It was equally clear that to restrict the sale of these was quite impracticable in the absence of legislative provision, and so in 1894 I suggested the introduction of the Bill which ultimately became law in 1907. During the intervening years the practice carried out was to purchase about a dozen lots of fertilisers annually, subject them to chemical analysis and publish the results, together with the names of the fertilisers and their respective vendors, so as to enable farmers to see the composition of at all events *some* of the materials purchased by them, and their suitability to the needs of soil and crops. At length, after surmounting many difficulties and obstacles which I have recently dwelt on elsewhere,* the Act was promulgated, and under its provisions more than 150 fertilisers were analysed last year. The result has been that the control of the sale of fertilisers has been organised with a surprising celerity. Difficulties of nomenclature have vanished; the employment of unscientific or misleading terminology has ceased; such terms as "guano" are no longer applied to non-nitrogenous manures; the faulty stating of percentages has been stopped; in the case of such articles as superphosphates definite grades have been established; the fineness of bone meal and of basic slag has been legally fixed; and all this has been done with the mercantile community acting in the most perfect accord with the technical advisers of the Government, and assisting the latter by proving their willingness to abide by the definitions which characterise the fertilisers law and its concomitant regulations, as they do the other two statutes referred to in the previous section.

Farmers can now be far more certain than ever before that the article they purchase is not appreciably different in composition from what they intend to buy.

Agricultural Produce.

Three legislative enactments have been mentioned. A fourth had been not only drafted by me for submission to Parliament, but had been introduced as one of the series of statutes intended to stimulate and protect producers, and had been actually read a first time in Parliament, when the prospect of Union obliterated for a time all legislation on minor matters; and so the Agricultural Products Bill was temporarily shelved. This Bill had also come into being through the connection of the Agricultural Department Laboratories with the administration of the Food Adulteration Act, and in consequence of the knowledge gained from the routine work of the latter the need was realised of taking legislative measures to foster the manufacture of Colonial articles of agricultural produce to an extent which could not be attained so long as they were subject to the competition of the cheap, inferior products that were being poured into the country from overseas. The articles whose manufacture in a pure condition the Bill was particularly designed to stimulate and protect were first of all the dairy products butter and cheese, but jam and grain products were also specially dealt with. The result of examining about eight hundred samples of butter had been to show that, eighteen or twenty years ago, the addition to butter of margarine and other foreign fats was of common occurrence,

* *Union Agricultural Journal*, March, 1911.

and frequently the so-called "butter" consisted entirely of these foreign fats. Then came a period during which supervision did its effective work, and for many years an adulterated butter was rare on the Cape market. The War opened the flood-gates for the import of tinned butters from abroad, and so brought about a change from the satisfactory condition that had come about; gradually it became no uncommon thing for butter to be found preserved with boric acid and coloured by means of tropœolin dyes. In addition, the sale of other animal and vegetable fats under the name of butter began to show signs of reviving. At length it became increasingly difficult to procure a pure butter in Cape Town, and so the Agricultural Products Bill, introduced in the interests of the farming community in general, would have been of special value to the Cape dairy farmer, for it was in butters imported from abroad that preservatives and dye-stuffs were first noticed, and the practice of making such additions to articles of local manufacture, when once it obtained a firm foothold in the land, would soon become general and difficult to eradicate.* Other undesirable practices have of late also been detected by chemical analyses in the Cape Province as having been introduced from oversea—for instance, the process of renovating butter by melting out the fat from the stale article and re-working it with milk or cream, subsequently placing it on the market as "fresh butter." Against all the practices enumerated above and others the Bill made provision, on principles which had also been adopted by the United States Department of Agriculture and by the Board of Agriculture of Great Britain. What has been said about butter may be taken as having a corresponding application to cheese, that commodity having been made from skim milk on the one hand or by the use of lard, tallow and oils on the other, while even margarine has frequently been found preserved with boric acid.

In jams, it was found, the use of cane sugar was being superseded by glucose, which is the thick syrup obtained by boiling starch with dilute sulphuric or other acid and evaporating the product obtained. The grain clauses in the Bill were inserted because of the practice of selling mixed flour or meal without notification. In every one of its phases it will be observed the proposed legislation had for its object the protection of the South African producer, who could do without the props of preservatives and sophistications, but was unable to make headway against the imported articles which were so sustained unless he too were allowed the undesirable and undesired priviledge of sophisticating his produce.

Cereals and Other Fodders.

More than twenty years ago† I carried on a short investigation into the composition of Cape fodder plants, in the course of which, struck by the small quantity of phosphates in a crop

* See also Senior Analyst's Report for 1908, p. 107.

† C. F. Juritz, "Colonial Fodder Plants and Woods," 1890, p. 27.

of oats grown near Port Alfred, I expressed the view that the soil on which the crop was grown would, if chemically examined, show a corresponding deficiency. In course of time one analysis after another demonstrated that such a lack of phosphates prevailed, not only in the neighbourhood first mentioned, but also in considerable areas of such districts as Willowvale, St. Mark's, Queenstown, Cathcart, Komgha, Hopetown, Malmesbury, Caledon, Bredasdorp, Swellendam, Riversdale, and George. Research has shown that nitrifying bacteria need phosphates for their development; hence lack of phosphates is apt to go hand in hand with retarded nitrification. Now phosphates are exceptionally needed by cereals—wheat, barley, oats, mealies, and rye. Some of the chief grain soils being poor in phosphates, these cereals cannot flourish, nitrogenous as they are, unless the deficiency be artificially supplied, and therefore I had advocated this course for many years.* But whatever I had said about some Cape *soils* I had never declared Cape *cereals* to be as a rule deficient in phosphates. One can argue from the latter to the former, but it is not possible to argue from the former to the latter. A poor soil may cause a deficient crop, but not necessarily a crop deficient in one particular constituent. Nevertheless, the snowball that I had set rolling gathered weight as it went, and so the first idea spread was that *all* the soils of the Cape Colony were poor in phosphates, and the next that the Colony's *cereals* exhibited the same deficiency. Accordingly, when a disease appeared amongst the horses at the large military establishment that existed some years back where the Government Agricultural College at Grootfontein is now situated, the malady was in a most sweeping manner attributed to deficiency of phosphates in the Cape oats; the stir thus occasioned is still within general recollection. The accusations brought against the Cape oats were quite kaleidoscopic in their variety: to the imaginary deficiency of phosphates was added (in imagination) lack of lime; then it was discovered that carbohydrates were wanting, and lastly, that there was an undue proportion of husk to grain. In the first instance a preliminary examination of Algerian, South American, Australian, Canadian and Cape oats was made in the Cape Town laboratory. In none of the five was lime deficient, and the Algerian, South American, and Cape oats contained a lower proportion of phosphoric oxide than the other two, so that, if they sinned at all, they sinned together; at the same time it was absurd to imagine that the difference in this respect could be sufficient to account for a sudden onset of bone disease in cattle.

The investigation of cereals having thus begun, it has been continued to the present day. The first extended series comprised fifty-two samples of oats grown in eleven separate Fiscal Divisions of the Cape Province. The conclusions arrived at were the following:—

* See "Agricultural Soils of Cape Colony," pp. 45, 47, 72.

1. As regards organic food material Cape oats are equal in value to those of other countries.
2. The average percentage of lime in Cape oats is normal.
3. The proportion of phosphoric oxide is somewhat lower than the averages of published results from other countries.
4. The small deficiency of phosphoric oxide is of less importance than would appear at first sight, for in *all* oats the proportion of phosphoric oxide relative to lime is large as compared with the requirements of animals, and the deficiency of the *latter* must therefore be made up to the animal from sources *other than oats*. This will be the case no matter in which country the oats are grown.

The nett result of these conclusions is that if an animal contracts a bone disease from being confined to oat rations, such disease will occur quite irrespective of the source of the oats, the latter cereal providing the animal with all the phosphates it needs for the bone structure, but an insufficient proportionate amount of lime.

The investigation was thereafter extended to wheat, and forty-three samples of the latter were analysed with a view to determine their feeding values. Six of these were imported from oversea; the remaining thirty-seven were grown in the Cape Province. The proteins of the Cape wheats were found to be as rule lower and the carbohydrates higher than in four out of the six imported wheats examined.

Immediately upon the conclusion of the wheat analyses a preliminary investigation of Colonial barley was begun, because of the oft-repeated statement that brewers had found it inferior to the imported cereal for their purposes. Samples were therefore procured from the Worcester, Robertson and Montagu districts, and analysed in the Cape Town laboratory. The alleged defect was that Cape barleys contained an excessive amount of undesirable nitrogenous constituents; however, the preliminary investigation revealed the proportion of nitrogen in the Cape barleys to be considerably lower than the proportions which characterise brewing barleys from oversea, so that, if a low proportion of nitrogen in itself indicate good quality in a brewing barley, the Cape barleys would be excellent. The opinion is, however, that what affects for the worse the brewing qualities of a barley is not so much the *quantity* of the nitrogenous constituents as their *nature*. The investigation is at the present moment being carried out on a scale comparable in extent with the oats and wheat investigations already referred to, and forty-six samples of barley, grown in seven separate districts of the Province, are now under chemical analysis.

It is intended to continue these investigations in connection with the other cereals, and with the co-operation of Mr. J. Burtt-Davy, F.L.S., steps have already been taken to obtain representative samples of maize. In this case, the Union of South Africa being now an accomplished fact, the samples are being collected not from the Cape Province alone, but from all parts of the Union where the cereal is grown. *Apròpos* of this latter phase of the investigation, the possibility of establishing the manufacture of maize vinegar as a staple South African industry has been considered, and in this connection the analyses of seventy-two vinegars were recently discussed by me before the Cape Chemical Society,** the conclusion being arrived at that whole maize and not maize grits would have to be employed for such a manufacture if it were desired to avoid the overwhelming competition of an imported vinegar prepared from damaged rice.

The present paper has already attained such a length that records of other investigations made in the Cape laboratories must either be condensed or omitted. So I shall just say, before leaving the subject of stock food plants, that, in addition to cultivated fodders, the nutritive values of several indigenous or imported stock food plants have formed the subjects of preliminary investigation. Of these plants I can do hardly more than mention the names.

Many years ago these investigations were commenced by determining the food values for stock of some of the commonest of the Karroo bushes, the "Draai bosje," as it is known vernacularly (*Diplopappus filifolius*), the "schaap bosje" (*Pentzia virgate*), the "vaal bosje" (*Atriplex halimus*), the "ganna" (*Salsola aphylla*), the "kouw goed" (*Augea capensis*), and the "vijge bosje," or rather one of the many plants that are spoken of by that name, that is to say, *Mesembrianthemum spinosum**. In 1896 some determinations were made of the relative feeding values of the leaves and stalks of lucerne plants, and of the leaves, light stalks, and woody stalks of "tagasaste." The opinion was then expressed that, provided the difficulties as to acclimatisation could be overcome, the last named might prove a valuable addition to our fodder plants, notwithstanding its volatile oil, which was apt to cause flatulency in horses.† Two years later a series of analyses of prickly pear (*Opuntia*) leaves were made, and comments made on the place that this article could take as part of a ration for pigs.‡ In 1900 a short investigation into the value of *Euphorbia caput medusæ* ("vingerpol") as a fodder was undertaken: as a succulent, nutritious fodder it compared, in general, favourably with the "ganna" bushes previously analysed, but its dietetic properties were interfered with by the presence of a resin. This resin, might, however, possibly be got rid of by boiling§. The next investigation of this kind pertained to *Erodium moschatum*, and represented the leaves and stems, gathered at a time when the plant was in vigorous growth, flowering and seeding freely.|| Other plants have been analysed with the same object, comprising amongst their number the vlei grass from the vicinity of Mulder's

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** *Vide* "Malt Vinegar and Maize Vinegar," in *C.G.H. Agricultural Journal*," of December, 1910.

* See "Colonial Fodder Plants and Woods," 1890.

† Report of the Senior Analyst, 1896, pp. 61, 62.

‡ Report of the Senior Analyst, 1898, pp. 63-66.

§ Report of the Senior Analyst, 1900, pp. 50, 51.

|| Report of the Senior Analyst, January-June, 1904, pp. 31, 32.

Vlei, and mealies and mealie cobs, the latter being compared with ordinary dried fodder*. Investigations of a similar nature were made during 1908 in regard to various species of prickly pear, and the fodder plants *Phalaris commutata*, *Festuca elatior* and *Paspalum dilatatum*, and during 1909 with respect to the Kafir melon (*monketaan*). Another investigation has been directed towards ascertaining the sugar content that can be acquired by beet cultivated in various parts of the country, and at various stages of growth.

Mineral Investigations.

The pecuniary worth of the chemical investigations conducted in the Cape laboratories is not always visible to the bystander—certainly not in the way wherein they proved themselves valuable in connection with the Thebus irrigation project alluded to on an earlier page; nor in the manner in which such an investigation seven years ago saved the Corporation of the City of Cape Town from paying £100,000 for the right of extracting a mythical asphalt from the gravel of Table Mountain in order to pave the city's streets; nor even in the way in which, still more recently, many persons were restrained from speculation while many thousands of pounds were lost by others who, notwithstanding the Government Analysts' reports of a contrary tendency, persisted in the belief that a fabulous wealth of platinum was concealed under the quartzites of the Witteberg Range. As a rule the value of scientific investigation is slow in proving itself: the instances just quoted are exceptions.

One series of investigations connected with the mineral wealth of the country deserves quoting here. I refer to the seven or eight dozen analyses that were made of salt taken from the salt-pans that are found in various parts of the Cape Province and Orange Free State. The results obtained were tabulated and commented on in a short paper published in the Cape *Agricultural Journal*,† and, while the purity of the salt produced was found to be equal to anything imported from oversea, on the one hand 28,000,000 pounds by weight of table salt were being so imported annually, and on the other £15,000 worth of salt was being prepared locally *in one year*, the output of a working capital of only £57,000.

Another subject on which there has been a certain amount of investigation is that of materials for pottery and earthenware. Clays from Kingwilliamstown, comparing well with Stourbridge fireclay, have been analysed, as well as ironstones resembling Torbay paints, from the same locality. At East London, Molteno and Cyphergat materials capable of producing good fireclays have been found, while kaolins or China clays from George and Oatlands have also been analysed.

A fairly exhaustive series of analyses of coal samples from almost every possible locality in South Africa has been carried

* *C.G.H. Agricultural Journal*, July, 1908.
† November, 1908.

out, so that the broad characteristics of typical coal from each of these localities is now well ascertained. These analyses were some three hundred in number, and, taken collectively, they constitute a fairly thorough investigation into the technico-chemical composition of South African coal.

All the above work—distinctly investigational in character when the summarised results are considered—was undertaken in the ordinary routine of the laboratories.

Milk.

In an earlier part of this paper allusion was made to the fact that the late Cape Government's Agricultural Products Bill had grown out of the analyses of butter and cheese that had been made in the Cape laboratories. But no word was said about milk. It would be strange indeed if I closed this paper without making any further reference to the eleven thousand odd samples of milk that have been analysed in the laboratories under my direction. In many cases milk of poor quality has been undoubtedly drawn straight from the cow, and the question has been raised whether the sale of such undoubtedly abnormal milk should be permitted. That point has been discussed by me at length elsewhere.* Frisian cattle are remarkable no less for the abundance of their milk than for its poor quality, and so a series of experiments was conducted on a Cape Town farm with a view to test the standard of milk supplied by Frisian cows, the effect of our climate on such cattle, and the possibility of improving the quality of the milk by cross-breeding. The inference from the investigation was that the quality of the milk would improve and its quantity diminish by Colonial breeding. I need scarcely refer to the paper read before the Bloemfontein meeting of this Association by Mr. Sinclair in 1909, wherein he tabulated some of the thousands of analyses of milk representing the Cape Peninsula supply that had been made in the Government laboratories for many years, and dealt exhaustively with the results arrived at. From a series of analyses made in the Eastern Districts of the Colony, and comprising over four hundred milk samples, a similar compilation was made by Mr. J. Muller, now Senior Analyst at Cape Town.† These are instances of the manner in which numerous individual and, primarily, purely routine analyses, added together, constitute investigations of the most valuable type, for it must never be forgotten that in scientific investigation, as in finance, it is care of the pence that ultimately places the thrifty in the possession of pounds. By thus hoarding up the analyses of individual milks for years, we have been enabled to gauge the variation of fat and other constituents in milk between summer and winter, and to note the difference in this respect between Kimberley and Cape Town, for instance, the milk of the former

* See Senior Analyst's Report for 1902.

† See *Union Agricultural Journal*, March, 1911, pp. 194-198.

place having been found to be some twenty per cent. richer in fat than that at Cape Town.

There are numerous other points that could have been brought forward in illustration of the idea with which this paper has been drawn up. In its opening paragraphs I suggested that the most valuable results are seldom, if ever, seized upon by eagle-swoops, but are the outcome of steady progress along a seemingly monotonous way; and I have just pointed, without entering into details, to the thousands of milk analyses which have been performed at Cape Town and Grahamstown, and from which we have built up a considerable amount of knowledge of the average composition of milk in various parts of the Cape Province. Only the other day, at an Agricultural Congress, complaint was made by a Transvaal representative that there had been no similar milk investigation in that Province. I trust that ere long I shall have the opportunity of rendering such a complaint out of date, but let me press the point that *we can get the information we seek only by carrying out a large number of analyses with monotonous insistence*, and the sooner we begin the sooner shall we arrive at a sufficient accumulation of data to enable us to express definite conclusions.

That there are other aspects of research and investigation of course I am perfectly well aware. Research in pure chemistry is by no means encouraged as it should be, in spite of the dazzling results that sometimes, as it were by purest accident, seem to follow from investigations begun without any such expectations —for instance, when William Perkin, endeavouring to synthesise quinine, happened to discover mauve, and so opened the door to the vast and wonderful coal-tar colour industry. There is an opposite danger in this country, and it is the danger to which I have alluded—the danger of being, in spite of the names by which we call our operations, ultra-practical in our so-called research, and so missing the fundamental units by which the really valuable investigation that we need will be built up. About eighteen months ago the editor of the *United States Experiment Station Record* deplored the lack of a treatise on horticulture in its scientific aspects.

"What a help [he said] such a book would be to both the teacher and the investigator! It would give the status of science in horticulture in such a way as to furnish a starting-point for original and productive investigation, and something to build on to.

I do not know whether the analogy is grasped, but much of what some have been calling our "routine work" is, with us, supplying precisely such a want as that deplored in the sentence just quoted. Collated in the way that we have been doing and hope to do in a greater degree—for we have in hand a great deal of uncollated data—these many thousands of analyses, by their cumulative and progressive effect, will form a broad foundation on which to build such a structure of investigation as the country needs. Here, as in other connections, "many a mickle makes a muckle." Do not misunderstand me: the mere aimless accumulation of data will probably be expensive and lead to nothing, but where routine work is in any case essential, the safeguarding and husbanding of its results may prove so valuable that it will be unwise and improvident to leave them where they can never be made use of for the general benefit. Let us not think, in our anxiety to get on with the superstructure, that we are wasting time on the foundations, because they are under the surface and out of sight, and so do not glint in the sunshine: they constitute a part of the building that we cannot afford to treat cavalierly because we wish to make a show with our granite and marble above. A single plant that has developed upon its own roots has a better prospect of enduring than a whole collection of cut flowers which for mere show are tied to sticks loosely stuck in the ground. Even foundations and roots, though underground, must be admitted to be of value, and it was because I wished to demonstrate something of that value and to illustrate how easily commonplace or routine work in chemical analyses—all the more if it be pioneer work in an unexplored country—directly connect with and point the way to investigations which appeal to the popular imagination with greater force that I was led to record these few phases of our work during the last quarter century.

International Congress of Applied Chemistry.—The eighth International Congress of Applied Chemistry will be held in Washington and New York from the 4th to the 13th September, 1912, under the patronage of the President of the United States. The Congress will be presided over by Dr. W. H. Nicholls. The Secretary is Dr. B. C. Hesse, 25, Broad Street, New York City, and the Secretary of the British Organising Committee is Mr. C. G. Cresswell, Society of Chemical Industry, Palace Chambers, Westminster, London, S.W., from whom a preliminary pamphlet may be obtained. The Congress will be divided into the following sections and subsections: Analytical Chemistry, Inorganic Chemistry, Metallurgy and Mining, Explosives, Silicate Industries, Organic Chemistry, Coal-tar colours and dye-stuffs, Industry and Chemistry of sugar, Indiarubber and other plastics, Fuels and asphalt, Fats, fatty oils and soaps, Paints, drying oils and varnishes, Starch, cellulose and paper, Fermentation, Agricultural Chemistry, Hygiene, Pharmaceutical Chemistry, Bromatology and Pharmacology, Photo-chemistry, Electro-chemistry, Physical Chemistry, Law and legislation affecting Chemical industry, Political economy and conservation of natural resources. Papers will be accepted for reading and discussion in all these sections, preference being given to those specially adapted for international discussion; these must be sent in not later than July 1st, 1912. It is understood that the Government of the Union of South Africa has been approached with a view to a delegate being sent to attend the Congress.

Similar invitations to take part in the deliberations and work of the Congress have been sent to all the Governments of the world, and all chemists, whether individually, or collectively as Societies, should, as a duty to their science and profession, put forth every possible effort for the complete success of the Congress, and they are asked to demonstrate to their respective Governments and to their fellow-countrymen that, in accepting this invitation of the President of the United States, the confidence reposed in them by their Governments has been fully justified. To this end the hearty and enthusiastic co-operation of chemists and allied professional and business men, and particularly of chemical and allied societies, is earnestly solicited.

TRANSACTIONS OF SOCIETIES.

South African Institute of Electrical Engineers.—Thursday, July 27th: J. H. Rider, V.P.I.E.E., President, in the chair.—"Atmospheric phenomena and their relation to the production of over-voltages in overhead electric transmission lines": G. V. **Adendorff.** The author dealt firstly with the varieties of atmospheric phenomena capable of causing disturbances, and then with the probable effect of such phenomena on overhead lines. Under the first head were comprised temperature effects, altitude effects, rain, snow, and hail storms, wind and dust storms, atmospheric electrification, and thunderstorms. Over-voltages were then considered, grouped under the heads of direct strokes, steady electrostatic stress, impulses or travelling waves, and standing waves or oscillations. Finally, the methods of protecting lines from over-voltages were enquired into.

South African Institute of Engineers.—Saturday, August 12th: F. H. Davis, President, in the chair.—"The metering of compressed air": J. L. **Hodgson.** Until recently the metering of compressed air had involved considerable difficulties, accuracy of measurement to within one per cent. had been attained by means of Messrs. Eckstein's calibration plant, erected at Ferreira, and serving as a permanent air standard for the Rand. The author proceeded to describe this plant. A detailed description of the method of measuring air flows by the orifice and manometer method was given, as well as the mechanism of the Venturi tube meter, and that of the weighted door type.

Royal Society of South Africa.—Wednesday, August 16th: S. S. Hough, M.A., F.R.S., President, in the chair.—"Note on the Heidjé Eibib, or stone mound of Namaqualand": Dr. L. **Peringuey.** The name is usually given to mounds of stone occurring in Namaqualand and elsewhere, the erection of which is ascribed to Hottentots. One such mound, recently opened, was found to contain portions of a skeleton. It is stated that these mounds are of two kinds.—"The secular acceleration of the orbital motion of the moon": E. N. **Nevill.** The principal recorded ancient total eclipses of the sun were critically examined, and the conditions of each eclipse calculated. It was not found possible to bring all these recorded eclipses into accord with the tables. Assuming a secular acceleration in the orbital motion of the earth, the origin thereof, and its effects on the motion of the members of the solar system were considered.—"Some observations concerning the transmission of East Coast fever by ticks": Dr. A. **Theiler.** It has been proved experimentally that (1) the brown tick imago, infected as larva, by which, in the nymphal stage, the disease had been transmitted, ceased to be infective for susceptible cattle; (2) ticks fed on animals rendered immune by inoculation were found to have been thus cleaned, and no longer transmitted the disease; (3) ticks infected in the larval stage, and passed on to a rabbit in the nymphal stage, lost their infectivity in the adult stage for susceptible cattle; (4) clean or infective ticks feeding on an animal that has recovered from East Coast fever do not transmit the disease in their next stage; (5) all ticks, though reared and fed under similar conditions, do not equally transmit the disease, a fact of which explanation is difficult.

Chemical, Metallurgical and Mining Society of South Africa.—Saturday, August 19th: W. R. Dowling, Vice-President, in the chair.—"Sinking operations at the Norma shaft, Kattowitz, Upper Silesia": B. C. **Gullachsen.** A description of the methods adopted by the Kattowitzer Aktiengesellschaft for overcoming the difficulties met with in sinking a shaft at the Ferdinand Colliery workings through layers of damp sand, quicksands, bands of clay, and soft sandstone.

NEW BOOKS.

Johnson, J P.—*The Mineral Industry of Rhodesia*, 9 in. × 6 in., pp. 90, 1 plate, interleaved. Longmans, Green & Co., 8s. 6d.

Durand, Rt. Hon. Sir H. Mortimer.—*A Holiday in South Africa.* 12mo., pp. xiv, 275. London: William Blackwood & Sons, 1911. 14 oz., 6s.

Schomburgk, Hans.—*Wild und Wilde im Herzen Afrikas: Zwolf Jahr Jagd- und Forschungsreisen.* 8vo, pp. xvi, 373. Berlin: Egon, Fleischel & Co. 1910. 36 oz., 8 marks.

Colville, Mrs. Arthur.—*One Thousand Miles in a machilla: travel and sport in Nyasaland, Angoniland and Rhodesia; with some account of the resources of these countries.* . . . 9 in × $5\frac{1}{2}$ in., pp. x, 312. Maps and illus. London, etc.: W. Scott Publishing Co., 10s. nett.

ADDRESSES WANTED.

The Assistant General Secretary (P.O. Box 1497, Cape Town) would be glad to receive the correct addresses of the following members, whose last-known addresses are given below:—

Aspland, C. Hatton, Witwatersrand Deep, Ltd., P.O. Box 5, Knight's, Transvaal.

Barton, Ernest Mortlock, Director of Works Department, Simonstown, Cape.

Bay, Dr. B., P.O. Box 5513, Johannesburg.

Bell, W. Reid, M.I.C.E., F.R. Met. Soc., M.I.E.S., P.O, Box 2263, Johannesburg.

Boulton, H. C., c/o Messrs. Pauling & Co., Ltd., Broken Hill, Rhodesia.

Brown, W. B., c/o Engineer-in-Chief, S.A. Railways, Cape Town.

Champion, Ivor Edward, P.O. Roberts Heights, Pretoria.

Crockett, John, 10, Transvaal Bank Buildings, Johannesburg.

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Mirrilees, W. J., 9, London Chambers, Durban.

Nichol, Thomas Thompson, P.O. Box 34, Springs, Transvaal.

Nicholas, W. H., Durban High School, Durban, Natal.

Nicholson, J. Greg, Leliefontein, Government School, P.O. Carolina, Transvaal.

Petersen, H. T., P.O. Box 5, Cleveland, Transvaal.

Preston, James, 89, Arnold Road, Observatory, near Cape Town.

Southwell, Miss Jessie, 270, Visagie Street, Pretoria.

Van Oordt, J. F., Harrismith, O.F.S.

THE PLACE OF CLASSICS IN MODERN EDUCATION.

By Professor Reinhold Friedrich Alfred Hoernlé, M.A., B.Sc.

§ 1. The major premise, which I take for granted in my argument, is that the control of education belongs to the community. Education, in the illuminating phrase of a recent American writer, is man-making. The State is profoundly interested in education because on the manner and substance of the training which is obtainable in its schools and universities will depend the intellectual and moral qualities of its citizens. I like to think of education, as Plato thought of it more than two thousand years ago, as a preparation for effective citizenship.

§ 2. Granted this premise, it follows at once that nothing deserves and requires the watchful care of the community more than the subject-matter of the teaching imparted in its educational institutions. What subjects are to be taught? At what stages in the child's development? In what manner? To what extent? All these are questions of which the periodical reconsideration is of the utmost importance. For there is always a danger that an educational tradition establishes itself which gradually gets out of touch with the living needs of a people. And whilst this is more apt to happen in the schools than in the universities, it is also more fatal in the schools just because by far the greater number of men and women get their only preparation for life there, and do not go to a university at all.

§ 3. Anyone who takes the trouble to read the signs of the times, especially in the English-speaking world, is well aware that the time has come when once again an overhauling of our educational system has become necessary. More especially, the teaching of Classics is the burning question of modern educational reform. Berkeley once said of philosophers that "they first raise a dust and then complain that they cannot see." The same rebuke may be applied even more fitly to the antagonists in the debate on the educational value of Classics. There is hardly any other question of national importance in which both sides have so often spoilt a good case by bad reasons. And in the dust of controversy some of the fundamental points have been neglected.

§ 4. An educational system, once established, is hard to criticise. Outside criticism is necessarily more or less ignorant and ill-informed. Inside criticism is inevitably biassed in favour of things as they are. An educational system is an organisation of experts who claim, just because they are experts, to be the sole judges of their own efficiency. With the sincerest intention of judging fairly, they are yet prejudiced in their own favour. They have to meet a criticism and a challenge, and they retort by calling in question the competence of the critic.

Think of the average schoolmaster's opinion of the average parent's educational ideas! "Odi profanum vulgus." The teacher, left to himself, is naturally the last to acknowledge the necessity of a reform of which he might himself be the first victim. He is content to teach what he was taught himself. And by an association of ideas which is illogical but humanly intelligible he is inclined to think that the system of which he is himself the product cannot be bettered. He judges the tree by its fruit, but then he is himself the fruit. And thus an educational system maintains itself by its own momentum, or, if you like, by its own inertia. What is the result? We have witnessed in the controversy which of recent years has raged about the Classics the half-pathetic, half-ludicrous spectacle of ill-directed attacks met by a blustering and uneasy defence—a defence which was successful only because the real weakness had not been laid bare. The defenders of Classical Education have taken up every attitude from apologetic defence to scornful defiance, according as the varying robustness of their consciences permitted or forbade them to doubt their own infallibility. The public, on the other hand, feeling dimly that something was wrong, was yet unable to analyse correctly and articulately the cause of the disease, and, in consequence, has had to submit to a good many hard names, *e.g.*, Philistinism, Materialism, Commercialism, and the rest of the opprobrious "isms."

§ 5. Under these circumstances, it is clearly the duty of everyone who has the interests of education at heart, and who is at the same time qualified by inside knowledge of our educational system, to bring the discussion back to the fundamental issues and to attempt an unprejudiced estimate of the place and value of Classical Studies in modern education. The main questions, as it seems to me, are: (1) In what lies the educational value of Classics at their best? (2) Does the amount and manner of what goes at present under the name of "Classics" in our schools and colleges secure a profitable proportion of this educational value? (3) If not, must we discard Classics all together, or is there a better way of teaching them, so as to retain them as a valuable element in education?

§ 6. I cannot do better than summarise the substance of the current criticism of Classics in the words of a man who has some claim to speak with authority, and who, at any rate, speaks neither without experience nor without sympathy. I quote from H. G. Wells's "New Machiavelli" the description of the hero's schooldays (pp. 72-77):—

"We were taught, as the chief subjects of instruction, Latin and Greek. We were taught very badly, because the men who taught us did not habitually use either of these languages. . . . . We were taught these languages because long ago Latin had been the language of civilisation; the one way of escape from the narrow and localised life had lain in those days through Latin, and afterwards Greek had come in as the vehicle of a flood of new and amazing ideas. Once these two languages had been the sole means of initiation to the detached criticism and partial comprehension of the world. I can imagine the fierce zeal of

[Renaissance men] teaching Greek like passionate missionaries, as a progressive Chinaman might teach English to the boys of Pekin, clumsily, impatiently, with rod and harsh urgency, but sincerely, patriotically, because they felt that behind it lay revelations, the irrestible stimulus to a new phase of history. That was long ago. A new great world, a vaster Imperialism had arisen about the school, had assimilated all these amazing and incredible ideas, had gone on to new and yet more amazing developments of its own. . . .

"There is no fierceness left in the teaching now. . . .

"So it was I occupied my mind with the exact study of dead languages for seven long years. It was the strangest of detachments. We would sit under the desk of such a master as Topham like creatures who had fallen into an enchanted pit, and he would do his considerable best to work us up to an enthusiasm for, let us say, a Greek play. If we flagged, he would lash himself to revive us. He would walk about the class-room mouthing great lines in a rich roar, and asking us with a flushed face and shining eyes if it was not 'glorious' . . . Glorious! And being plastic human beings we would consent that it was glorious, and some of us even achieved an answering reverberation and a sympathetic flush. . . . . We all accepted from him unquestioningly that these melodies, these strange sounds, exceeded any possibility of beauty that lay in the Gothic intricacy, the splash and glitter, the jar and recovery, the stabbing lights, the heights and broad distances of our English tongue. That indeed was the chief sin of him. It was not that he was for Greek and Latin, but that he was fiercely against every beauty that was neither classic nor deferred to classical canons.

"And what exactly did we make of it, we seniors who understood it best? We visualised dimly, through that dust and the grammatical difficulties, the spectacle of the chorus chanting grotesquely, helping out protagonist and antagonist, masked and buskined, with the telling of incomprehensible parricides, of inexplicable incests, of gods faded beyond symbolism, of that Relentless Law we did not believe in for a moment, that no modern Western European can believe in. . . . And then out one would come through our grey old gate into the evening light and the spectacle of London hurrying like a cataract, London in black and brown and blue and gleaming silver, roaring like the very boom of Time. We came out into the new world no teacher has yet had the power and courage to grasp and expound. Life and death sang all about one, joys and fears on such a scale, in such an intricacy as never Greek nor Roman knew. . . .

"That submerged and isolated curriculum did not even join on to living interests where it might have done so. We were left absolutely to the hints of the newspapers, to casual political speeches, to the cartoons of the comic papers, or a chance reading of some socialistic pamphlet for any general ideas whatever about the huge swirling world process in which we found ourselves. I always look back with particular exasperation to the cessation of our modern history at the year 1815. There it pulled up abruptly, as though it had come upon something indelicate. . . ."

§ 7. Few will deny the substantial truth of this picture. Few will fail to recognise that Wells has here voiced a revolt to which their hearts respond. I am not thinking merely of the average school-boy who generally learns too little of the Classical languages to come to love them for the sake of the wonderful world of ideas to which they are the gate. Even the student who becomes enthusiastic in his classical studies must surely at times doubt the value of his enthusiasms, and wonder whether the time spent on Classics might not have been better spent otherwise. However much a man knows of Greece and Rome, he must be singularly lacking in sympathy and catholicity of interests if he does not, now and then, weigh sadly the heavy price at which he has purchased a scholar's pleasures—the vast fields of modern Literature in all civilised languages with which he cannot, even at best, hope to gain more than a superficial acquaintance; the long stretches of History which must remain for him blank spaces, or a confused medley of hazy happenings shot through, here and there, with more vivid episodes; the rich wonders of modern Science which he must leave unexplored. Surely, the price which we are paying for a knowledge of Latin and Greek is great indeed. Is the sacrifice worth the results achieved?

§ 8. This brings me back to the original question. What is the educational value of the Classics? To answer this question we must make a distinction of supreme importance. We must distinguish between the ancient *languages* and the *ideas* of which the languages are but the vehicle. Our classical education at the present day fails because it neglects the distinction. Will any school-master, will any College Professor even, dare to deny that the bulk of our Classical teaching in South Africa is linguistic? We praise the Classics for the world of ideas which they open to us, but we occupy our pupils with grammars and dictionaries. We recommend the Classics for their philosophy and their art, we call them the fountains of our civilisation and culture, but in teaching them we omit the ideas which live perenially, and feed our pupils only on the dry bones of dead languages. The practice might be defensible if we wished to train a nation of "scholars," but who even pretends that this is our aim? Except the few students who continue the study long enough to pass beyond the linguistic stage, all others are condemned by our system to remain in the antechamber. They never enter the inner temple at all.

Hence my main theses, briefly, are:—

1. That the real educational value of the Classics lies in the thorough knowledge and enjoyment of ancient philosophy, history, literature and art.

2. That the linguistic studies have little value except as a preliminary to this appreciation of the masterpieces of the ancient mind.

3. That all who never get beyond the linguistic stage, or whose classical education remains mainly within the linguistic stage, miss all that makes a classical education worth having.

§ 9. If these principles are accepted, the practical proposals required to give effect to them are: Let us throw overboard the study of the ancient *languages*, or at least of *Greek*, and read instead in the best translations obtainable as many of the masterpieces of Greek and Roman Literature as we can, interpreted by the best hand-books and commentaries which scholars can put at our disposal. If we can give our students a background of ancient History, Philosophy and Art, we need not deplore the loss of the languages. We shall have given them a better education than all the present linguistic study can give them. "Sad experience shows," says a recent Oxford writer, "what dense and incredible ignorance about the ancient world, what it was, or when it was, or where it was, or how it affects us, is possible to some undergraduates who are supposed to have passed through a classical education." Our present system fosters this ignorance by misdirecting the attention and energies of the students to the languages. As a result, our so-called "liberal" education does anything but liberate the mind, anything but set it free in the world of ideas. Granted that it is a fine thing to be able to read the great Greek and Roman writers in the original texts with the thorough understanding of a scholar—does it follow, I must ask again, that our educational ideal should be to train a nation of scholars? Does it follow that to become a scholar is the only way to get a liberal education? If it does follow, what a ghastly failure is our actual education which claims to be "classical" and "liberal"! But, fortunately, it does not follow. For, surely, it is possible to enjoy Homer though one knows no Greek; to be inspired by Plato though one has to read his dialogues in translations; to learn from the history of the Athenian democracy or the Roman Empire, though one has to go to Grote and Gibbon instead of to Thucydides and Tacitus. But what do we do in our schools? Do we train the pupils' eye and mind by contact with the concrete achievements of the ancient mind? Do we teach them how to appreciate the beauty of Greek Art? Or to absorb the fine thoughts of Greek thinkers? Or to learn from the genius of the Romans for Law and Politics No—we feed them on grammar and composition. Hence, in the name of true culture, I should like to say to every school and college:

Abolish compulsory Greek: introduce compulsory Hellenism.

§ 10. I may be asked: Why not abolish Latin as well? On general principles, it seems to me, it should be possible to give a sound liberal education even without Latin, provided Roman writers are studied in good translations and Roman history and constitution in the works of men like Gibbon and Mommsen. Still, a stronger case can be made out for retaining the linguistic study of Latin than of Greek. Latin is necessary to the historical study of English, French, Italian, and other modern languages; it is indispensable to the historian and lawyer for the study of documents, treaties, codes of laws, etc.; it is still, if not a language of intercourse, at least a living language, being the official medium of the Roman Catholic Church. Even so, it may be doubted whether it is necessary to make Latin compulsory for everyone even in secondary schools. There is a great deal to be said for the German system of having schools "with" and "without" Latin. In dropping the languages and substituting good translations and handbooks, there is, of course, the danger of cramming, but even the Oxford defender of Classics, whom I have quoted above, acknowledges: "The most sordid of crammed handbooks is better than a blank mind." The truth is that cramming can be killed only by good teaching. Awaken the pupil's interest, make him love his work, and he will never be tempted to cram. And it is easier, after all, to interest pupils in ideas and facts than in grammatical rules and irregular verbs.

§ 11. In fact, the strongest argument in favour of the change which I advocate is that it would revive interest in classical studies. Let a boy once be fired with genuine enthusiasm for the heroes of Greek and Roman history, let him once through a good translation catch something of the beauty and fascination of Homer or Sophocles, and he will often spontaneously be led to the study of the language. This seems to me the true educational order in which interest in the language should grow up in the pupil's mind. The predominantly linguistic study, as at present practised in our schools and colleges, is a waste of time and labour. Its educational results are insignificant, compared with the effort squandered and with the results which might have been obtained by a better method. And only too often the pupil carries away nothing but a deep-rooted disgust. For this reason, too, I have no sympathy with those who recommend the study of the classical languages merely on the ground of their being a good "mental discipline." The argument degrades the Classics. And, besides, one knows but too well from experience what sort of teaching to expect from those who believe that only in grammatical exercises is educational salvation to be found.

§ 12. There was a time when there was no "modern" side to modern education; when boys spent the bulk of their school-time on Latin and Greek, and learnt next to no science, no modern languages, no history, no geography. None the less they got what, in spite of its one-sidedness, was a good education. For they did so much Latin and Greek that they passed beyond the preliminary stage. They gained sufficient mastery over the languages to turn out a neat copy of Latin prose in flowing Ciceronian periods, or a set of Greek verses which would at least scan. They learnt to feel delight in the handling of language. They required an ear for rhythms and cadences, and the balance of sentences. And the taste thus formed, the keen desire for the right word in the right place, made them also more fastidious about their own mother-tongue, more skilful in its use, more careful of a "good style." Moreover, having got beyond the linguistic difficulties over which the beginner stumbles, their attention was set free to take in the thought and substance of ancient literature, add in this contact of young modern minds with ancient wisdom and art there was real and genuine education.

§ 13. Those were the ideal days of classical education. They have passed away through the pressure and the claims of "modern" subjects. Room had to be made for these in the curriculum. And rightly so, for it would have been an intolerable paradox if the scientific achievements of the modern mind had not been used to contribute materials to education, or if the curiosity of the young about the world in which they live, their country and its language, history, products, relations to other countries, etc., had not been encouraged, guided, satisfied by instruction. Hence, to make room for these things, the time given to classics had to be cut down more and more. But, unfortunately, the cutting down was done in the wrong way. The most valuable forms of classical study were surrendered, the least valuable retained. The substance of thought and culture was dropped, the preliminary struggles with language and grammar remained. All that makes classics the toilsome grind for which so many students hate it survived; almost all that gives fascination and interest, that feeds the imagination and stimulates the intellect, was abandoned. The result is that classical studies have largely lost their appeal, and, propped up by compulsion, drag on an artificial existence. And the worst is that, even so, the average boy learns so little of either Greek or Latin at school or college that it has hardly any educational value for him at all. For we have sacrificed all that is best in the study of the Classics.

§ 14. We have, then, to readjust our methods of teaching the classics to the needs and ideals of modern education. We have to cast out of our schools the classical *languages* in order that we may re-introduce classical *culture*. The proper places for the philological study of Greek and Latin, the training of "scholars" in the traditional sense of the word, are the Universities. There we can have a small number of experts and specialists to be interpreters between the ancient and the modern mind. There we can encourage and endow the first-hand study of the ancient languages. But, except for these special students at the Universities, let us drop the languages, and retain, or rather re-introduce, the substance of classical culture through good translations and hand-books. The problem, then, is: *Can we retain the substance, and sacrifice the languages?* In other words, cannot the works of classical writers maintain an important and valuable place in modern education, *if they are studied in good translations*, rounded out by an interpretation which will ultimately be derived from the authoritative exposition of a few competent scholars?

§ 15. I believe this to be possible. And the proof is that our religion rests on a translation the original of which not one in a hundred Christians can read. How few, even of Greek scholars, ever look at the Greek text of the New Testament? How many can read the Old Testament in Hebrew? Nor is the translation perfect. Did we not a short time ago have a "Revised Version" Yet our religion has not suffered from the fact that we all read the Bible in our mother tongue. In fact, the very scheme I am proposing for Classical education exists already in religious education. That education is based on a translation, expounded by second-hand interpretations, which filter down through clergymen and ministers from the Professors at Universities and Theological Seminaries. They are the "scholars" in Greek and Hebrew. They are the experts versed in the niceties of interpretation. They have at their command the whole apparatus of "Higher Criticism," the facts of history and tradition, the latest results of linguistic research and scholarship, the latest finds and excavations. Whose religion is the worse because he cannot read the Bible in Greek and Hebrew? Or because he has not been trained as a specialist in Theology?

§ 16. Here, then, is the remedy for Classical Education. Let us drop the languages, but let us continue and increase the study of the masterpieces of Greek and Roman writers in the best translations which our scholars can furnish. Let us add the study, in picture or cast, of works of art, and, above all, the study of the history and thought of Greece and Rome, taught so as to make clear their significance for the general world-history, and their living influence on present-day civilisation.

Surely this is an ideal of which the realisation would not be unworthy of the best efforts of all who care for preserving to the modern world an education in what has been well-called "The Humanities."

Agricultural Research Grants.—The Imperial Treasury has sanctioned the allocation of funds amounting to a maximum of £50,000 per annum for distribution by the Board of Agriculture and Fisheries in order to promote agricultural research in accordance with a scheme which will secure for each group of the problems affecting rural industry a share of attention roughly proportionate to its economic importance. With this object in view eleven groups of subjects have been arranged for, *viz.*: (1) Plant physiology, (2) Plant pathology and mycology, (3) Plant breeding, (4) Fruit growing, including the practical treatment of plant diseases, (5) Plant nutrition and soil problems, (6) Animal nutrition, (7) Animal breeding, (8) Animal pathology, (9) Dairying, (10) Agricultural zoology, (11) Economics of Agriculture. In addition to these a sum of £8,000 will be available for special investigations, for which no other provision is made. The Board of Agriculture hopes to secure the services of trained men for work in connection with this scheme by offering during each of the next three years, twelve scholarships, each tenable for three years and of the value of £150 per annum.

SOUTH AFRICAN CLIMATIC CONDITIONS IN RELATION TO AVIATION.

By Robert T. A. Innes, F.R.A.S., F.R.S.E.

The ideal climate for flying-machines is one of high barometric pressure and windlessness, or steadiness of wind. It must be confessed that in these two requirements the climate of the South African Plateau is not ideal. Over the greater part of inhabited lands the barometer stands at 30 inches, whereas over the Transvaal it is but 25 inches. Winds, although generally moderate in force, are a marked feature of the climate of South Africa; calms are rare, and sudden wind-storms are not uncommon. These features will be enlarged on.

Without an atmosphere, neither an aeroplane flying-machine nor a balloon could rise from the ground, but the denser or heavier the atmosphere is, the more easily will these machines rise and remain suspended. If we imagine the atmosphere to become as dense as water, flying-machines would tend to float on its surface like a cork on water. The atmosphere is not nearly dense enough to float an aeroplane, but it will float a balloon which has a reservoir filled with a gas which is lighter than the air. An aeroplane rises because it is propelled through the air; the propelling-power is derived from fans driven by an engine. The motion of the fans displaces the air and the machine moves forward, the inclination of the planes of the machine causing it to ascend or descend.

These simple principles, which are known to every aviator, show us at once that the lower density of the air over the South African Plateau is unfavourable in itself. It is true that, on account of the decreased density of the air, the engine will revolve more freely, which to a great extent compensates for the decreased density, but friction effects in the engine are increased, and taken altogether, there is a loss. As aeroplanes in Europe have not infrequently ascended to altitudes much greater than that of the South African Plateau, we learn that the decrease of density is fortunately not sufficient to interfere materially with the success of aviation.

The matter of the winds is undoubtedly the most important in either ballooning or aviation. In the highest regions of the atmosphere, say from 20,000 to 30,000 feet, the movement of the air has always a westerly component—that is, the air moves from N.-W.,W. or S.-W. to S.-E., E. or N.-E. This wind is too high to have any influence on aviation, but it is important to remember that whatever be the surface wind, the wind will veer, as the altitude above the surface is increased towards the west. This is the normal state of affairs, but in disturbed conditions of the atmosphere, especially during the summer season on the High Veld, many cross-currents of air may exist; thus the writer has seen a surface wind from the N. at a height of about 2,000 to 3,000 feet; this was replaced by a current from the S., whilst higher up still (5,000 to 10,000 feet) the current was from the W. These movements were indicated by the motions of the different layers of clouds. Where these various strata mix, there would probably be turbulent motion, which would be immediately fatal to aviation. A very slight knowledge of the clouds will be sufficient to warn the aviator when these conditions are present. During summer-time, over the greater part of South Africa thunderstorms are to be expected, and these sometimes spring up very suddenly; in some cases these storms are associated with the line-squalls; in any case, the atmosphere is in a disturbed condition, and full of what the aviators have already pithily named as "holes." All these condition are practically inimical to successful aviation. If, however, these turbulent conditions are absent, the winds at an altitude of anything over 100 feet are undoubtedly regular and constant over a very large area, and if taken advantage of, might be rendered of great use in long-distance aviation. Over Rhodesia, the general surface wind is E.-S.-E.; over the Transvaal N.-E.; over the Orange Free State N., and over the Western Province of the Cape S. These statements are too general to claim exactitude, and are merely given as a first approximation, and as a peg on which to hang an example; thus if an aviator wished to travel from, say, Pretoria to Capetown and back, taking advantage of the winds, he would pursue an easterly path going and a westerly one returning, something like this: Pretoria, Johannesburg, Bloemfontein, Port Elizabeth, Capetown, returning by Port Nolloth, thence across the Kalahari Desert to Mafeking, and then to Pretoria. On two days out of three the winds would be favourable, although now and then a consecutive five to seven days of adverse winds would be met.

Meteorologists generally record only surface winds, and much work must be initiated and carried out before reliable wind itineraries for aviators can be issued, but the writer feels sure that the conditions in South Africa are peculiarly favourable for such. It is more difficult to state the precision with which the force and direction of the winds could be prognosticated, so that if commercial aviation became possible, predictions could be issued; but there is no doubt that the indications of the barometer will furnish generalities which the experienced aviator could use with good effect. Even at present it is possible to foretell when the conditions indicate the establishment of an anticyclonic system (region of high barometric pressure) over South Africa, with its accompaniment of gentle winds; the breaking up of an anticyclone sometimes takes place very rapidly, for reasons which are at present obscure. During the opposite conditions of affairs (low pressure over the interior of South Africa) forecasting becomes much more difficult, and one must often be content with the general warning that the atmosphere is ripe for the establishment of disturbed conditions, which may develop into rain-storms or line-squalls at very short notice. But the aviator has also to be on his guard when the weather is ideally perfect, when a cloudless sky and gentle zephyrs prevail. On such days the heating of the soil by the sun's rays gives rise to innumerable atmospheric whirls, which sometimes become visible as dust-devils; the diameter and length of these whirls vary greatly, but it is seldom that one is less than 20 to 30 feet in diameter. An encounter with these whirls would probably mean an upsetting of the unfortunate aeroplane.

It is noticeable that the show-flights made by aviators who visit South Africa have all taken place at the time of sunset; at this time of the day the atmosphere is relatively quiescent, whirls and sudden gusts of wind being unusual. Still, better conditions prevail at sunrise, but it would be impossible to get an audience at that time.

A book to be called "Charts of the Atmosphere for Aeronauts and Aviators" is being issued by the authorities of the Blue Hill Meteorological Observatory, near Boston, U.S.A., and will be published by John Wiley and Son, of New York. This book, it is announced, will deal fully with the bearings of meteorology on aviation.

The successes already achieved by aeroplanists in the Northern Hemisphere are sufficient to show that the investigation of the non-surface movements of the atmosphere over South Africa call for investigation by means of kites and balloons, following the lines of similar work in the Northern Hemisphere.

THE 1911 COMETS.—Several photographs of Kiess's comet, 1911*b*, were taken at the Transvaal Observatory during August, and it is intended to publish the whole series in one of the Observatory Circulars. The comet was visible to the naked eye for about a week, but was never brighter than the fifth magnitude. With respect to the more recently discovered comets it is noted that, during October, Brooks' comet, 1911*c*, had been increasing in brightness, and on the 21st, with the R.A. of 12h. 40m., and a N.D. of 15 deg. 13 min., it had attained a magnitude of 2.8, and had been visible in the morning for over a week. Quenisset's comet, 1911*f*, and Beljawsky's comet, 1911*g*, had both decreased in brightness, the former being of 6.8 magnitude and the latter 3.4 on October 20th. The position of Quenisset's comet was on that date 15h. 40m. R.A., and 26 deg. 47 min. N.D., while that of Beljawsky's comet was 14h. 53m. R.A., and 1 deg. 52 min. S.D. According to Prof. Nijland's observations at Utrecht, the tail of Beljawsky's comet was 15 deg. long on October 1st, and of a broad parabolic type.

THE UNIVERSAL RACES CONGRESS.

By Mrs. Julia F. Solly.

At the end of July a congress was held in London of special interest to the Educational section of the South African Association for the Advancement of Science: it met to

"discuss in the light of modern knowledge and the modern conscience the general relations between West and East and between so-called white and so-called coloured people with a view to encouraging between them a fuller understanding and a heartier co-operation."

It was fitly preceded by a meeting of anthropologists, professors of one of the youngest of sciences, but a science that has already undermined certain cherished convictions and shown that, as Dr. Frazer states, "even superstition has rendered great service to humanity"; while in his last great book on "Totemism and Exogamy" he has shown that even Parliamentary government, *i.e.*, government by the grand Council of the nation, is neither an English nor Aryan, but a human institution.

The increased facilities for intercourse and the increase of travel, both European and non-European, has produced a revolution which compels all thinking people to give some consideration to the problems of how to deal with varying civilisations, and the "Conflict of Colour," as Putnam Weale calls it, is an ever present fact; nor can we forget that in the "War of the Civilisations," Europe has shown frequently not only her newest weapons but also her oldest barbarities. Yet Sir Oliver Lodge well points out,

"in cold blood and in the light of sanity and reason the settling of disputes by means of bodily violence is manifestly uncivilised and barbarous."

A few years ago an Asiatic race beat in fair fight a great European and Christian nation—a nation whose might and predatory desires at one time disturbed the peace of many English statesmen, and with this Asiatic people England formed an alliance; it marked an epoch not only in the history of the Empire, but in the history of the world: the consequences lie yet in the lap of the gods.

For many years the missionary and an occasional scientist were the only Europeans who endeavoured to observe the golden rule towards people of other civilisations; the majority, whether traders, travellers or soldiers, for the most part so behaved as to lead an Imperial poet to declare that "East of Suez, there ain't no Ten Commandments," forgetting that morality and equity know neither latitude nor longitude, and there is a certain fixed minimum of obligation recognised by all but the lowest and most degenerate of savages. Sir William Butler, in his recently published Autobiography, reflects thus (of the Zulus):

"People wonder how men whom we call barbarous have so often in their lives a natural level of right and wrong, a sense of good and evil, which we imagine belong to ourselves and civilisation only. They forget that in nature everything has a right and a wrong side, and that it is only in art you have to teach people on which side the shadow falls."

The Chairman of the Congress was the Hon. Pember Reeves, Agent-General for New Zealand in London; the President was Lord Weardale. Honorary members and supporters hailed from fifty different countries, and included twenty-five Presidents of Parliaments, and the same number of British Governors and British Prime Ministers. The writers of papers alone included representatives of over twenty civilisations, and, where possible, natives of the race most affected read papers on special problems. On the Honorary Committee were the following South Africans: The Hon. J. W. Sauer, M.L.A., acting Prime Minister, Sir James Rose-Innes, the Rev. J. S. Moffat, Dr. Abdurahman, Olive Schreiner, the Rev. Ramsden Balmforth, Mrs. Saul Solomon, Dr. J. J. McClure, and the writer. The Rev. W. Flint, D.D. represented the local (Cape Town) auxiliary Committee, Dr. Rubusana a section of the educated natives, and with him the Chief Dalindyebo (Tembu), Tengo Jabavu, the well-known editor of *Imvo*, was present, and read a paper; the Rev. W. C. Willoughby represented the missionary societies, Mr. Thomas Searle the Women's Christian Temperance Union, and Mr. Sampson, M.L.A., Organised White Labour; many individuals were also present from South Africa, among them Miss Molteno, daughter of the first Prime Minister of the Cape, and throughout the country are many "passive" members—*i.e.*, subscribers for the valuable books and papers in connection with the Congress.

No resolutions were passed; the Congress was pledged to no political party or scheme of reform, though the Imperial Government and Parliament gave valuable assistance, direct and indirect. Neither religious nor political questions were touched on, but certain aspects of Government were dealt with by Sir Henry Johnstone and Sir Sidney Ollivier, both of them distinguished and successful administrators.

Though at present "'tis an hour inhospitable to reason's tempering word" in many parts of the world, yet the effort to gain some common ground of action, some generally recognised binding principle, is imperative; as the Head of Lovedale (Dr. J. Henderson) truly says, "the claims for racial justice based on religion make effective appeal only to those who submit themselves consciously to its guidance. But racial questions are coming rapidly to be the concern not only of Churches and Governments, but also of the individual citizen, and demand teaching on lines of policy and general utility, as well as of moral obligation." Readers of Putnam Weale's books know how he emphasises these points from a purely worldly and practical point of view, and on the last day of the Congress Baron d'Estournelles de Constant (member of the Hague Tribunal) read a paper on "The respect due by the White race to other races," surely if we are a superior race, *noblesse oblige*—alas that it often does not!

If prejudice seems too strong at present, either in our Indian or our African Empire, let us consider how rapidly opinion has changed on two equally important matters. A hundred and fifty years ago the most respectable merchants in my native town of Liverpool thought it no shame to be traffickers in slaves; the remains of the slave market there recently disappeared, and Goree Piazza is still the centre of the still lucrative West African trade. Sixty years ago the most brilliant civilian in Europe, Ferdinand Lasalle, fell in a duel: where, among Europeans, is slavery now defended? And how completely among our own people has duelling disappeared! But though slavery has been abolished, the slave-owning instincts remain; wherever one finds differential treatment advocated on account of colour, or brutal and savage punishments demanded in dealing with savages, there are the instincts fully alive, and need both law and public opinion to keep them in check. Not many years ago, a white nation, reputedly civilised, tortured its prisoners, and another nation boiled the head of an enemy slain in battle over the camp-fire; though these things called forth indignant protests from the whole world, the mere fact that they were possible shows how unequally civilisation operates even among white people.

How greatly race and religion may separate white races the painful history of England and Ireland shows. "Violence and injustice beget one another," says Mahaffy, and there are few Englishmen who can read without shame a record of their country's dealings with a nation to whom they owe Christianity. Similar or worse horrors obscure the dealings of Russians and Finns, Germans and Poles, Austrians and Italians: in the latter case not even a difference of religion existing to palliate the conduct of the stronger. It is necessary to emphasise this, as one is apt here to regard colour as the dividing-line, but history says otherwise.

The meaning of race and nation and the problem of race equality, together with the general conditions of progress, took up the first day, dealt with by Professor von Luschau, Monsieur Fouillé, Mr. John Robertson, M.P., Dr. Rhys Davids, Dr. Sergi, Sister Nivedetta (India), and Mr. Spiller, to whose energy the Congress was mainly due.

The second day began with "Tendencies towards Parliamentary rule" by Dr. Lange of Brussels, followed by accounts of such in China, Japan, Turkey, Persia, India, Egypt and Hayti, and "The Rôle of Russia in bringing White and Yellow races together" was dealt with by Dr. Yastchenko of Dorpat, in Russia.

Then came peaceful contact between civilisations, mostly dealt with by Professors of International Law, of whom no fewer than 150 supported the Congress; and problems of economics such as wages and markets, dealt with by professors of economics.

The third day dealt with the modern conscience in relation to racial questions, and fitly began with "International Ethics," by Professor Felix Adler of New York, one of the main promoters of the Congress, followed by "The Jewish Race" from the pen of Israel Zangwill.

The African questions come naturally under this heading, dealt with by Tengo Jabavu, Mr. Blyden of Sierra Leone, and Sir Harry Johnstone; while Professor Du Bois of Atlanta University dealt with the Negro in America.

The last day, July 29th, was given to positive suggestions for promoting inter-racial friendliness, beginning with a paper by Baron de Constant already referred to, and ending with "Suggestions for a World Association for encouraging inter-racial goodwill," by Professor Mead, of Boston, Director of the International School of Peace.

A stimulus may be given to a more scientific study of our various native races here, for every year it is less possible to act wisely without knowledge. Papers on various points are read at each annual meeting of this Association, and collectively they should be valuable. A book on the lines of Mr. Dudley Kidd's "Kafir Socialism," written with a less violent anti-Socialist bias and a more scientific outlook on humanity, should be invaluable to administrators and law-makers here. There are already works on native law and native medicine and tribal peculiarities which need combining and collating. May not many of our South African difficulties come from trying to force an ultra-individualist civilisation on an inherent Socialist people (as, according to Mr. Kidd, all the Kafir races are), and has the Cæsarean motto, "Divide and rule," which we have taken to mean break down the power of the chiefs, always been successful? What is the secret of the prosperity of Basutoland? What are we to infer from the intellectual capabilities of Dr. Rubusana, Tengo Jabavu, Mangena, the Kafir barrister, and Harold Cressy, the half-caste Zulu, who was the first coloured man to take a degree at the South African College? Many of our natives and coloured people are seeking opportunities for education and self-culture—is it wise to force them to seek it, as Dr. Rubusana did, in America?*—and the white race is reported to be lagging behind in that desire for knowledge which it is the object of this Association to encourage.

Says Dr. Frazer:

> "Government, private property, marriage and respect for human life are the pillars on which rests the whole fabric of civil society: shake them, and you shake society to its foundations."

The best men of every race unite in supporting them. Though abstract justice may appeal little to the native mind, the release of the Pondo Chief Sigcau, on a writ of *Habeas Corpus*, by the Chief Justice of Cape Colony from the prison into which the

* Mrs. Sprigg writes: "Dr. Rubusana was educated entirely at Lovedale, and his degree was *sent* from America in recognition of his work in translating the Bible; but many educated Natives do go to America, and I agree it is a very great pity."

Cape Prime Minister and Attorney-General had flung him must have sent a thrill through all coloured South Africa and outweighed a thousand unjust decisions of white juries trying coloured prisoners.

Science knows no party nor bias, therefore one appeals with confidence to a scientific association to promote in every way possible the dealing with all our problems by the light of modern knowledge, and anthropologists as well as statesmen are occupied in Psyche's task of sorting the seeds of good from the seeds of evil; even though the ideal time lie far ahead, "when the bars of creed and speech and race that sever shall all be fused in one humanity for ever."

Note.

The following letter from the Rev. James Henderson, Principal of Lovedale, was read at the last meeting of the local Auxiliary Committee of the Universal Races Congress:—"It has long been my opinion that the question of mutual race obligations and responsibilities should be dealt with on a basis wider than that with which missionaries are primarily concerned. The missionary passion is an experience limited to the comparatively few; and the claims for racial justice based on religion in the narrower sense of that term make effective appeal only to those who consciously submit themselves to its guidance. But racial questions are coming rapidly to be the concern not only of Churches and of Governments, but of the individual citizen, and demand teaching on lines of policy and general utility as well as of moral obligation. I have been convinced that in such a country as Great Britain, of which so considerable a proportion of her youth have to go forth to lands in which their life must be lived in presence of backward and subject races, there should be teaching on this subject in the common school, and the State should see to it that, from an early stage, broad, reasonable, and just views on this vitally important subject should be inculcated. I consider that this Congress may prove the complement of the great Missionary Conference held at Edinburgh last year, and I trust that a like blessing from God may attend it."

NOTE UPON THE OCCURRENCE OF SCORODITE IN RHODESIA.

By A. E. V. Zealley, F.G.S., A.R.C.S.

Scorodite was mentioned* by the present writer as occurring at Umtali, etc. Its mode of occurrence at Gwanda † and at Tuli ‡ was briefly described.

Distribution.—Scorodite (hydrous iron arsenate), $Fe_2O_3.As_2O_5.4H_2O$, is known to occur in several widely separated localities in Southern Rhodesia. The localities in which the mineral is known to occur are as follows: Gwanda (Champion Claims), Tuli, Odzi (Champion Mine and Cairn Dhu Mine), (Umtali), and Victoria.

It further might be expected to occur, but has not yet been recorded, at the following localities where arsenical pyrites is known to be present: Farvic Mine (Gwanda), Kimberley Mine (Mazoe), Slate and Arcturus Mines (Enterprise), Bessie Mine (Umtali), Sabiwa Mine (Gwanda), Clutha and Ancient Mines (Umtali), etc.

Occurrence.—In each of the above-named localities where the mineral is found, it occurs in masses in the gossans of mispickel lodes, being an alteration product of that mineral. The lodes occur in various members of the ancient schist series (quartzite, hornblende schist, banded ironstone, etc.).

Associates.—The scorodite is associated with mispickel and various minerals representing (1) the original associates of the mispickel—actinolitic amphibole, galena, blende, pyrite, chalcopyrite, pyrrhotite, vein quartz; (2) minerals representing the decomposition and interaction of the original minerals of the lodes (mimetite, cerussite, malachite, azurite, sulphur, limonite, and (?) arsenolite,§ (3) mispickel|| (the mineral from which it was derived); and (4) minerals derived from the decomposition and separation of the impurities of the mispickel (? annabergite, gold).

Nature.—The mineral occurs in two main forms—compact amorphous, and crystalline. It is generally mixed with quartz, limonite, and the white mineral alluded to above. Mispickel and the other minerals named are less common associates. The colour varies chiefly from grey to green and brown, dark-grey, grey, greenish-grey, apple-green, yellow-green when mixed with mimetite, brownish when altering to limonite, and whitish. When occurring as thin coatings or in the massive amorphous state it

* Eighth Annual Report of the Rhodesia Museum, 1909, pp. 8, 28 and 32.

† *Rhodesian Mining Review*, April 20th and June 1st, 1910.

‡ Ninth Annual Report of the Rhodesia Museum, 1910, pp. 15 and 31.

§ A soft white mineral is commonly associated, but this I have not identified; it is not, however, arsenolite.

|| Löllingite (iron diarsenide) has not been proved to be present in any of the specimens.

is greenish-grey, and when crystalline it has a pretty greenish-grey to pale-green, semitransparent vitreous to adamantine and resinous lustred appearance. The crystals are all very small and in aggregates, but many of them show good faces. The compact, close-grained variety often has a marbled appearance suggestive of serpentine. In some specimens grains and crystals of mispickel may be observed to be altering marginally to scorodite.

Alteration.—As may be gathered from the above remarks, scorodite is observed to alter to limonite and possibly also to arsenolite—arsenic trioxide (As_2O_3)—but this latter mineral needs to be carefully tested for, and the author was not able to detect it.

Composition.—A quantitative chemical analysis of the mineral from Gwanda made by Mr. J. B. Bull gave:—

Arsenic pentoxide	50.53 per cent.
Ferric oxide	33.49 ,,
Water (combined)	15.98 ,,
	100.00

The material used for analysis was a mixed sample of amorphous and finally crystallised green scorodite. A little quartz was observed to be present.

Economics.—The mineral was first brought to my notice whilst Curator of the Rhodesia Museum on account of considerable bodies of it having been pegged for gold. Free gold is associated with the mineral at Gwanda and apparently elsewhere, but since the mineral appears to be only a surface capping, it is not likely of itself to be important as a gold ore. At a small depth the gossan gives place to lodes of arsenical pyrites from which the gold is less easily extracted; interest in it as a gold ore has somewhat decreased therefore. Still the mineral has considerable importance as an indicator of arsenical pyrites which commonly contain gold and silver in amounts which may be profitably extracted.

Soya Bean Rubber.—The manufacture of a synthetic substitute for indiarubber has recently been patented in Germany. The basis of this preparation is the oil of the Soya Bean which is subjected to the following treatment. Nitric acid is allowed to act upon the oil in such a manner as to reduce it to the consistency of a thick paste. This paste is repeatedly washed with an alkaline solution, after which it is heated to a temperature of 150 degrees Centigrade. A homogeneous substance is thus obtained which possesses the property of elasticity, and, in addition to resembling true indiarubber in other ways, is declared to be capable of vulcanisation.

SOME NOTES ON THE TRYPANOSOMIASES OF RHODESIA.

By Llewellyn Edgar Williams Bevan, M.R.C.V.S.

When selecting a subject for a paper to place before this Association, I felt that a few notes on the trypanosomiases of Rhodesia might prove of interest, inasmuch as so many branches of science are concerned in the elucidation of the varied problems presented by these maladies. But it was obviously impossible in a paper such as this to deal adequately with a study of such magnitude, and I have had to limit myself to a brief review of the subject, emphasising those features which particularly relate to this country, or have been the subject of personal observation and research.

The term "trypanosomiasis" includes certain diseases of man and the lower animals caused by the invasion of the blood-stream by minute flagellated protozoa called trypanosomes (Τρύπανον, a borer, σωμα, body) from the characteristic movements when viewed under the microscope.

The manner in which these parasites are transmitted from sick to healthy animals varies, but, as far as the trypanosomiases of this country are concerned, the most common method of transmission is by the bite of the so-called "tsetse fly," a fact which has been long recognised and has given rise to the name "fly disease," which is popularly applied to the trypanosomiases of animals. It is impossible to determine when these infections were first introduced into Rhodesia, and whence they came, but the earliest of modern explorers of this country, Livingstone, Kirk, Baines, Selous, Harvey Brown, and others encountered the "tsetse fly," and recorded the heavy mortality of stock which followed its bite. Many of the areas of infection defined by them exist to this day, although the devastating passage of rinderpest during 1896 apparently caused a check not only to the disease but to the "flies" themselves, which diminished considerably in numbers and distribution. I am obliged to my colleague, Mr. Rupert Jack, Government Entomologist, for a map which shows very concisely the present and past distribution of *Glossina morsitans* in Southern Rhodesia. This indicates that recently the "tsetse fly" has to some extent regained ground, and Neave has made the same observation, confirmed by the natives in the northern territories.

The economic importance of these animal trypanosomiases is greater than appears at first sight. Large areas of valuable territory are rendered inaccessible by animal transport and cannot be opened up, or, when served by a railway, agricultural, pastoral and mining development is severely handicapped if not impossible. And when it is remembered that some three hundred thousand human beings are said to have succumbed to sleeping sickness in Uganda during the past few years, the gravity of the recent extension of this plague in Rhodesia cannot be over-estimated. Moreover, the danger which menaces us is beset with more than usual difficulties by reason of the uncertainty which exists as to the identity of the species of trypanosome and the manner in which the disease, which is of exceptional virulence, is spread. For while human trypanosomiasis in the past has been intimately associated with the *Glossina palpalis,* recent cases seem to have been contracted where this fly is not known to exist. Until these uncertainties are cleared up adequate methods of prophylaxis cannot be devised, and the possible limits of the danger not only in this country but in the sub-continent cannot be defined.

The trypanosomes are Protozoa of the class *Flagellata,* whose usual form is spindle-shape or fusiform, varying in different species and in many circumstances. The body consists of a thin outer periplast surrounding an inner granular endoplasm. About the centre of the endoplasm is a trophonucleus, believed to be largely concerned in nutrition, while situated generally near one extremity is another mass of chromatin regarded by some as a kineto-nucleus, by others as an extra-nuclear centrosome. From this a faint strand proceeds which ends with a little bead—the blepharoplast—from which arises a flagellum running through the endoplasm to the ectoplasm, which it raises into a fold, known from its festooning as the " undulating membrane." The flagellum may project as a free lash beyond the parasite, such portion being termed the free flagellum. Some diversity of opinion exists as to which end of the parasite must be considered the anterior extremity, but in this paper the non-flagellated end will be regarded as the posterior. The endoplasm often appears vacuolated, and chromatoid granules are scattered in it in varying size and numbers. Some authorities describe longitudinal striations which traverse the body and afford a certain contractility to the organism, and produce variations in shape.

The trypanosomes are capable of movement, the undulating membrane, free flagellum and contractility of the body taking part in locomotion. The degree and manner of movement is often characteristic of a species; thus the *Tr. vivax* of animals encountered in Northern Rhodesia is so called on account of the rapidity and violence of its passage through the microscopic field.

The greatest importance has been attached to the morphology of the trypanosomes, and elaborate systems of measuring and differentiating have been devised, with the result that innumerable species have been identified. The smallest irregularity in any specimen has prompted some extremist to create a new species, with the result that at the present day the classification of African trypanosomes is in a state of chaos. The chief points seized upon for this purpose have been:—

(*a*) Measurements, such as the length and width of the various portions of the parasite and the total length of the whole.

(*b*) The shape and position of the various elements.

(*c*) The festooning of the undulating membrane, and the presence or absence of a free portion of flagellum.

(*d*) The presence of vacuoles and chromatoid granules, etc.

Such details would appear to be of purely academic interest; nevertheless, practical issues of the greatest importance to this country have arisen from them; for this reason I refer to them at some length.

It will be remembered that in the year 1902 Dutton and Todd, during their investigation upon human trypanosomiasis, encountered in horses in Gambia a trypanosome and distinguished three forms of the parasite, namely—

(1) "Tadpole forms," 11 m. to 13 m. long by 0.8 m. to 1 m. wide.

(2) "Stumpy forms," the body of which was short and squat, 16 m. to 19 m. long by 3.5 m. wide. Free flagellum short.

(3) "Long forms," 26 m. to 30 m. long by 1.6 m. to 2 m. wide, with a long free flagellum.

Later, in 1908, Montgomery and Kinghorn announced that they had found in cattle near Broken Hill an identical parasite.

This discovery stimulated careful study into the animal trypanosomiases of South Africa, with the result that trypanosomes of dimorphic type were found in Chai-Chai and Zululand by Theiler, Portuguese East Africa by Connacher and Jowett, and Southern Rhodesia by Bevan, but having slight features of difference from those described by Montgomery and Kinghorn. The most marked difference was the absence of the long flagellated form, and this circumstance gave rise to considerable controversy between the various schools, some authorities maintaining that the original disease encountered by the Liverpool observers was caused by a multiplicity of parasites rather than by one assuming two types. It was found that the trypanosome of cattle in Southern Rhodesia showed neither the very long form with free flagellum nor yet the very small organism described as "tadpole" forms. It differed also in the last respect from that found by Theiler and Jowett. But while experimentally endeavouring to make a comparison between the parasite of Broken Hill and Southern Rhodesian cattle, a result was obtained which threw a new light on the subject.

The circumstances were briefly as follows: Six fat-tail sheep at Broken Hill were inoculated in February from a cow dying of typical trypanosomiasis, and were sent by rail to Salisbury. These animals all reacted, but no trypanosome with undoubted free flagellum was ever encountered in any of them. From sheep No. 2 a white rat was inoculated. Three days later trypanosomes were found in the blood, of the long free flagellated variety, in apparently pure culture. These were at first suspected to be *Tr. brucei* or *Tr. lewisi*, but this was disproved, for day by day as the infection progressed the long forms with free flagellum became less numerous, while other forms of all graduation from the long form to the "tadpole" type made their appearance.

Coincidently with the shortening and disappearance of the free flagellum and the gradual rounding of the posterior end, a shrinking of the undulating membrane, which became almost inappreciable in the tadpole form, was noted. The gradations were not acute, but one type merged into another, so that it was impossible to determine where the long forms ceased and the non-flagellated types began.

The observation further gave rise to a theory which I advanced at the time, and which recent experiences of other workers seem to support, namely, that such circumstances as the production of anti-bodies by the host, or the unsuitability of the medium for the existence of the parasite, gave rise to the smaller forms which may be regarded as *types de résistance*. I was perhaps too bold when I advanced the suggestion that the numerous varieties of animal trypanosomiases met with in the continent of Africa may have had a common origin, their subsequent minor points of difference having been brought about by natural conditions of passage, transmission and environment. This certainly cannot be disproved, for such conditions have not and cannot be duplicated in the laboratory, and I maintain that the results obtained in laboratories far removed from a supply of natural virus in natural conditions are entirely artificial, and that the parasites so studied adapt themselves to their new surroundings and assume unnatural characters.

Bagshawe, in the Sleeping Sickness Bulletin No. 18, records this hypothesis and advances the experience of Doflein in support. This worker draws attention to the influence of age, food and other factors upon the morphology of trypanosomes, and instances the change in size and form when *Tr. brucei* is transmitted from rat to hedgehog. He says:

"the dimensions of the creature, its mobility, the size of the nucleus and blepharoplast, and above all the relative position of these—all these characters are not only labile in the natural state, but can be influenced by animal passage and artificial culture."

He hints at the possibility of the conversion of one apparent species into another. Wendelstadt and Fellmer showed by experiment how *Tr. brucei* in the blood of adders and tortoises developed forms much smaller than the normal, and how that when the strain was returned to rats (*i.e.*, highly susceptible hosts), very large trypanosomes made their appearance.

Having advanced this hypothesis with some temerity, it was with great satisfaction that I found so great an authority as Bruce adopting a scale of measurements on a percental basis expressed in the forms of charts or curves, giving the relative prevalence of various types. These charts show a remarkable overlapping or resemblance between various species considered distinct. By this system it was shown that the variety of *Tr. dimorphon* met with by observers in Khartoum closely resembled the *Tr. brucei* encountered in Zululand in 1894 and in Uganda, 1909, and indeed, Bruce asks whether it is not possible that Dutton and Todd's original *Tr. dimorphon* may not have really been *Tr. brucei*. At the risk of labouring the point, it may be recalled that when Theiler sent horses into the old area at one time infected with *Tr. brucei*, they became infected with a trypanosome of dimorphic type. There is no doubt also but that the type of animal trypanosomiasis in certain parts of Rhodesia has changed. Old hands have told me of the acute symptoms which rapidly followed the exposure of horses, donkeys, mules and cattle to the bite of the "tsetse fly" in the Hartley district. Men from Natal could not draw any distinction between the disease as it was in 1892 to 1896 from that of which they had had experience in the Delagoa Bay districts. At the present time quite a high percentage of oxen suffer from a very mild infection from which they recover, and equines appear to be immune. May it not be that with the arrival of civilisation the trypanosome, attenuated by constant passage through wild animals, become exalted in virulence in new and highly susceptible hosts, in which, again, by acclimatisation it has once more become attenuated?

This discussion may also be extended into the study of the human trypanosomiasis of Rhodesia and Nyasaland. Two observers, Stephens and Fanthan, have drawn attention to the peculiar morphology of a trypanosome in a case of sleeping sickness from this country. I may say that their strain was obtained from an European, W. A., who apparently contracted the disease in the Luangwa Valley or some other part of North-East Rhodesia. This patient arrived in Hartley, and his blood was brought to me by Dr. Mackenzie for examination. Trypanosomes were found in it, and, by the courtesy of Dr. Heygate Ellis, I secured a quantity of virus and originated a strain of the trypanosomiasis, which I have been carefully studying since November, 1909. During this period I have not encountered the phenomenon described by Stephen and Fanthan, namely, that among the short and stumpy forms some have the nucleus at the posterior (non-flagellated) end. I certainly have seen distorted forms of the parasite, which have become altered in such a way that the nucleus has appeared posterior to the centrosome, but these might have been artifacts.

I did not feel justified in announcing the discovery of a new species. The necessity for care in such a diagnosis is obvious; for, if we have in Rhodesia to deal with a new trypanosomiasis, due to a species of trypanosome concerning which we know nothing, our difficulties are the greater since there is no guarantee that the old and tried methods of prophylaxis will be of avail in arresting the spread of the disease.

Thus we see how important is the study of morphology, and yet how dangerous is the dogmatic differentiation of species by morphological features alone. For it must be remembered that the trypanosome is a plastic body, swimming in a medium varying in viscidity, specific gravity and chemical composition; the examination of the details of the parasite requires the adoption of certain methods of technique which vary with different workers, and are open to discrepancies attributable to the individual factor of the operator. Even with the same worker, using the same methods, results vary to a considerable degree, and many other controlling tests are required before one is justified in declaring the identity of the organism under observation.

But it must not be thought that I am endeavouring to discount the value of exact study into morphology and the information derived thereby. Bruce, while lamenting the tendency towards multiplying unnecessarily the number of species, offers also an excuse for precise study of morphology in conjunction with other tests on the grounds that

"if there is some well-marked difference in two trypanosomes, even if alike in shape, such as their power of setting up disease in certain animals, their mode of spreading from the sick to the healthy—it may be in one by 'tsetse flies,' in another by *Stomoxys* or *Tabanus*, or by other means—then, naturally, it is of great practical use to distinguish them by different specific names."

But close attention to the morphology or appearance of the parasite is also of great value in another connection. The theory I advanced as to the possibility of variations in shape being brought about by conditions unfavourable to the parasite has recently received confirmation from several authorities working in the field of therapeutics.

Nuttall observed degenerative changes in *Tr. brucei* consequent upon arsenophenylglycin treatment. He found that:

"whereas before treatment 95 per cent. showed blue-staining protoplasm protruding beyond the blepharoplast in the characteristic beak-like manner, already one hour after treatment only five per cent. of the parasites were free from granules, and none showed the beak-like process posteriorly. After two hours all the trypanosomes showed granules. After three hours . . . nine per cent. had become rounder or were breaking up."

Thomas made similar observations after the administration of atoxyl, and Hindle has obtained similar results with *Tr. gambiense* after treatment with arsenophenylglycin. In the clinical study of a case, therefore, such variations may be found to afford indications as to—

(*a*) The natural resistance of the patient.
(*b*) The virulence of the parasite.
(*c*) The effect of remedial agents applied.

The complete life-cycle of the trypanosome has not been definitely worked out, although, as we shall see later, it is a matter of practical importance.

In the peripheral blood the usual method of increase is multiplication by longitudinal division. The kineto-nucleus divides by mitosis followed by mitotic division of the trophonucleus.

"From the new blepharoplast produced by division a new flagellum grows out either close beside the old one or at some distance from it. The body of the trypanosome widens, and after the production of two kineto-nuclei, two tropho-nuclei, two blepharoplasts and two flagellas, begins to divide from the anterior end backwards." *

As to schizogony or sporogeny of the parasite, the greatest confusion exists. Moore and Breinl described certain "latent bodies" which Fanthan has recently described as non-flagellate stages found especially in the lungs, spleen and bone-marrow, during periods of decrease of trypanosomes in the peripheral blood of the host. The non-flagellate body contains the nucleus and kineto-nucleus, the cytoplasm and flagellum having disintegrated, and is supposed to have a definite capsule which renders it resistant. Under certain conditions, it is claimed they can be seen to grow and flagellate, turning into trypanosomes.

But none of the present theories appear to be completely satisfactory. It is known that during the course of an infection the peripheral blood contains from day to day varying numbers of parasites, increasing or disappearing in definite cycles.

It is generally assumed that during those periods when parasites are absent, or rather are not visible in the peripheral blood when examined under the microscope, that the latent or resistant stage occurs in some of the organs (spleen, bone-marrow, lungs). Nevertheless, such apparently sterile blood is infective by inoculation into susceptible animals. Bruce has conducted filtration experiments and has found the filtrate non-infective, arguing therefrom against an ultravisible stage of the organism. Filtration experiments, however, are liable to many fallacies. The viscidity of the material plays an important part in its passage through the porcelain. If, therefore, a minute form of the organism were embedded in a protoplasmic matrix, it is conceivable that it might fail to make its way through the filter. One of the features of trypanosomiasis is a curious alteration in the blood known as agglutination: this or some similar change would perhaps interfere with filtration results.

An interesting phenomenon is met with after the application of certain therapeutic agents, many of which cause the rapid disappearance of the organism from the peripheral blood, which, however, reappears after a certain period. Subsequent exhibitions of the drug fail to produce the same result—the parasite having acquired a tolerance or immunity to the agent. The phenomenon has given rise to the system of applying a second drug having no chemical relation to the first. A drug, to be successful in sterilising the host of the parasite, must be parasitropic but not organotropic. Many drugs or combinations of drugs have been claimed to possess these desired properties, but unfortunately, in spite of the optimism of the lay press, it must be admitted that a specific has not yet been found. Many agents, while successful or nearly successful in eradicating the parasite,

* Tobey.

produce such profound pathological effects in the patient that the remedy is almost as bad as the disease.

Professor Ehrlich has recently entrusted me with the conduct of some experiments with a new trypanolytic, and I had hoped to come here with a tale of another triumph to be added to the list of successes of the eminent German scientist. The experiments, I regret to say, are not yet completed.

We have yet to seek an entirely satisfactory chemical remedy, and I think it is to immuno-chemistry that we must turn, since there are many indications that success will be met with in that direction. Let us study these more closely.

In the first place there is abundant evidence that there exists naturally in the animal organism certain elements antagonistic to trypanosomes. What these elements consist of is not known, but they are found in the serum, and in certain organs such as the spleen.

For example, some species of animals offer great resistance to infection by certain species of trypanosomes—a feature of great value in differentiation. Man was held to be resistant to *Trypanosoma brucei*, and it was at one time thought that *Tr. gambiense* was non-pathogenic for the larger animals. Unfortunately, it is now known that cattle and antelopes, in certain conditions, can harbour this parasite. I have also shown that the so-called *Tr. rhodesiense* is more highly pathogenic for mules, sheep and small laboratory animals than many of the animal trypanosomes.

Theiler found that his Chai-Chai and Zululand trypanosome

"proved not to be pathogenic for every rabbit which was inoculated in the first place and not at all for guinea pigs."

I also found great difficulty in establishing a strain of the trypanosome of Southern Rhodesia, my small laboratory animals resisting inoculation with natural virus, but eventually becoming infected after repeated inoculations or increasing doses, their resistant elements probably becoming exhausted thereby. Moreover, a strain once established appears to accommodate itself and become subsequently infective with greater certainty, possibly because the trypanosome gains immunity against elements opposed to it.

Another Rhodesian trypanosome—namely *Tr. vivax*—is only pathogenic to equines and bovines; laboratory animals have a natural resistance to it.

Laveran has recently stated that sheep readily become immune or tolerant to trypanosomes, but sheep are for me the most easily obtained and most suitable laboratory animals, and I must admit I have never once found one of the fat-tail or half-bred colonial variety resistant to or recover from artificial infection. Again, in chronic cases we find a balance established between parasite and host. Game may harbour *Tr. brucei* and, in some circumstances, *Tr. gambiense* unharmed; their blood, however, giving rise to a fatal infection when introduced into a less resistant subject. "Fly-struck" cattle often acquire a tolerance to the organism, but in practice we frequently find such a balance broken down under conditions unfavourable to the animal—hard work, exposure to rains, starvation. Conversely, when treating such animals, the most effective trypanolytic agents will probably fail unless associated with favourable hygienic conditions.

These instances point to a very valuable " first line of defence " in dealing with trypanosomes, and our modern knowledge of vaccine-therapy suggests a method whereby this may be reinforced. It may be that the favourable results of drug treatment have depended upon such principles rather than upon the sterilising effect of the agent.

This paper is assuming such alarming proportions that I will not go deeply into the subject of the symptoms of these diseases. A few points, however, may be of interest.

As I have said before, the animal trypanosomiasis of Southern Rhodesia is, in the majority of cases, of a mild type, a few animals only succumbing to the acute form and dying in the early febrile stages. There seems to be some evidence that the severity of the disease bears a relation to the extent to which the animal has been submitted to infection—that is, as far as we know, to the bite of the " tsetse fly."

One may divide the outbreaks into three categories:—

1. In which the cattle have died rapidly and of the acute form of the disease, generally those animals which have lived in a " fly " area and have been constantly submitted to infection.

2. In which the cattle have died of the sub-acute or chronic form of the disease, generally those animals which have passed occasionally through a " belt."

3. A mixture of 1 and 2, generally in herds which have lived on the edge of a " fly zone." Laboratory experiments seem to support such an explanation.

In this country, where African Coast Fever is always to be feared, deaths of the first type are liable to cause alarm, as the animal may die fat and without the usual symptoms of anæmia and cachexia, commonly regarded as characteristic of " fly disease."

With regard to the human trypanosomiasis of Rhodesia, there is one feature which appears to support the opinion of Stephens and Fanthan that it is a distinct entity, namely, the quite extraordinary œdema of the face produced in infected sheep and rabbits.

In my sub-inoculations made with the W.A. strain this symptom was most marked, and distinguished sheep inoculated with the human parasite from those inoculated with the animal strains on Broken Hill or Southern Rhodesia.

Recently I have, through the kind assistance of Doctors MacKnight and Ellacomb, been able to establish a strain of human trypanosomiasis obtained from a patient infected on or near the Luapula in the Congo. Up to the present neither sheep nor rabbits infected with this virus have shown the same enlargement of the head.

In my animals somnolence has seldom been noted, and the name "sleeping sickness" could not be applied to the disease in them. I may mention that I have, more than once, been struck by the close resemblance between such infected rabbits and those dying at the same time from rabies.

The question of the method of *transmission* of trypanosomes is of the utmost importance, and, unfortunately, is the one concerning which the greatest uncertainty exists. I may be forgiven for dealing with it at some length.

It will be remembered that Montgomery and Kinghorn expressed the opinion that the animal trypanosome which they encountered at Broken Hill could be transmitted not only by *Glossina morsitans*, but also by *Stomoxys calcitrans* and a species of *Lyperosia*. Such a suspicion caused considerable alarm, inasmuch as it upset the pre-existing theory of the strict interrelation of the animal trypanosomiases and the "tsetse fly," and necessitated immediate prophylactic measures; for the newly incriminated flies were abundantly present throughout the country and other parts of South Africa, and by no means as restricted in distribution as *Glossina morsitans*. Moreover, at the time, no special embargo was placed upon "fly-struck" cattle, which were widely distributed and with the game constituted a potential reservoir of virus. In Southern Rhodesia official regulations were immediately enforced to deal with the situation, preventing the movement of cattle out of "fly" areas and quarantining large numbers of slaughter stock from the north. Such restrictions naturally caused great inconvenience and financial loss to the stock-owning community, and gave rise to vigorous protests from all sides, with the result that an extraordinary amount of evidence was advanced which emphasised in a very marked manner the fact that, as far as the trypanosomiasis of stock in Southern Rhodesia is concerned, a strict inter-dependence exists between the disease and the "tsetse fly."

I think I am correct in stating that up to the present, in these territories, no case of animal trypanosomiasis has been encountered where the possibility of previous exposure to the bite of the "fly" could be positively excluded. Moreover, in the absence of the "tsetse" the disease has failed to spread, in spite of the prevalence of other biting flies, as, for example *Stomoxys*, *Tabanidæ*, *Hippoboscæ*, *Hæmatopotæ*, etc.

At the laboratories at Salisbury *Stomoxys* are present at some times of the year in vast numbers, and I have had infected animals standing side by side with healthy susceptible animals for months without one of the latter becoming infected, although there was no reason why mechanical transmission should not have occurred; in fact, methods were adopted to encourage it. Moreover, in experimental small animals the number of trypanosomes in the peripheral blood is always far greater than in natural cases. Again, certain infected cattle, having been removed from a "fly belt," were depastured in a district free from "tsetse" where some of them succumbed. The Government therefore placed ten young oxen from a clean district in constant contact with them. *Tabanidæ, Hæmatopotæ* and *Stomoxys* were here present in vast numbers, the former constituting a veritable plague to man and beast; nevertheless, none of the young oxen became infected.

On the strength of the vast accumulation of evidence exonerating the biting flies other than the "tsetse," the Government felt justified in rescinding these very irksome regulations—a step which there has been no reason to regret.

In this connection it should be metioned that Jowett, working in Cape Town with the trypanosome of Portuguese East Africa, claims that in one instance the parasite was conveyed from a rat to a sheep by mechanical transmission.

Under the term *Tr. pecorum*, Bruce includes the trypanosomes of dimorphic type which I have previously referred to, and one which he found in domestic animals in Uganda, the carrier of which he considered was most probably a *Tabanus* and not a *Stomoxys*. If his suspicion is correct, the animal trypanosomiasis of Southern Rhodesia must be excluded from the group.

A similar unfortunate uncertainty exists as to the method of transmission of the human trypanosomiasis of Rhodesia and Nyasaland—*i.e.*, the disease caused by the so-called *Tr. rhodesiense*. This is a fact greatly to be regretted, inasmuch as the methods of dealing with sleeping sickness based upon the supposition that the sole transmitter was the *Glossina palpalis*, may be quite inadequate, if, as is suggested, the disease is contracted in the absence of this species. But our experience in Southern Rhodesia points to the great necessity for care in determining whether "tsetse flies" are inhabitants of a district. It is not sufficient to make a hurried search through a locality or to visit it only at long intervals.

Areas, well known as "fly belts," have been visited time after time without a *Glossina* being encountered. Thus Mr. Jack visited the Lomagundi district in November and found *Glossina morsitans* in considerable numbers on the banks of certain dry streams. Returning to the same places in March, he found few if any "fly" in the old situations, but some isolated specimens distributed about the veld—chiefly in Mopani belts.

In the apparent absence of *Glossina palpalis, Glossina morsitans* has been accused of transmitting the human malady, but up to the present definite confirmation of the suspicion is not forthcoming. It may be that the Commission, under the skilful direction of Dr. Kinghorn, may put the matter to definite proof.

It certainly seems strange, if so widely distributed a fly as *Glossina morsitans* is the offender, that cases are not far more numerous. Of course, we know that the usual method of transmission of trypanosomes by *Glossina* is "cyclical" rather than "direct," and that only a small percentage of flies are infective. This limits the danger, but, given a reservoir of virus, the number of infectible *Glossina morsitans* in a "belt" must still be very great.

Bagshawe points out that certain climatic atmospheric or telluric conditions may be necessary before the *Glossina morsitans* can assume the *rôle* of *Glossina palpalis*. Neave, as the result of a tour through the infected area, drew attention to the strange occurrence of cases in certain huts in certain villages—these usually the bachelor's huts, which he pointed out were the dirtiest and were occupied by visitors to the kraal. This feature does not point to infection by *Glossina morsitans*, but rather to some insect inhabitant of human dwelling-places, such as the *Ornithodorus*, floor-maggot, flea, bed-bug, etc. Dr. MacKnight has tried to transmit the disease from a native patient to healthy dogs by the bite of *Ornithodorus moubata* without success, but Bagshawe points out that time was not allowed for a cyclical development in the ticks to be completed.

I have also been experimenting with the same species of tick, in the adult and intermediate stages, both by interrupted feeding and by allowing long intervals to elapse between the feeds, with interesting results which cannot yet be published. At any rate, until the actual transmitter is proved, it is improper to loosely incriminate any insect, especially one so widely disseminated as *Glossina morsitans*. The fear caused by unfounded statements may seriously and unfairly handicap the progress and development of this country.

Although I have dealt but superficially with my subject, I have drawn attention to the many branches of the question requiring scientific research and investigation. For those who are less interested in the scientific than in the economic aspect of the subject, I would emphasise the necessity for well-staffed and adequately-equipped laboratories on the spot, where these diseases can be studied in natural conditions and with greater hope of success.

TRANSACTIONS OF SOCIETIES.

Cape Chemical Society.—Friday, August 25th: Prof. B. de St. J. van der Riet, M.A., Ph.D., President, in the chair.—"The utilisation of lime sludge from acetylene generators": Prof. B. de St. J. **van der Riet.** The sludge was being used at Stellenbosch for whitewashing as well as for manurial purposes. It consisted chiefly of slaked lime with calcium sulphide. For gardening it was necessary to get rid of the latter. The sludge was allowed to settle in perforated tanks, the water draining away and leaving a fairly stiff residue. Mixed with potash and crushed bones the author had found it an effective fertiliser.—"Note on an insect wax from Stellenbosch": Prof. B. de St. J. **van der Riet.** The wax occurred on myrtles, and was produced by a coccus. It was freely combustible and, when softened by heat, was capable of being drawn out into long threads. The insects yielded about 30% of wax.—

"The use of ether in the analysis of metals and alloys": Prof. P. D. **Hahn**. A note on the investigations of Rothe, Mylius, and Huttner with regard to the removal of iron and gold from their solutions by means of ether.—"The occurrence and distribution of manganese in the Western Districts of the Cape Province": W. **Versfeld**. A short account of various localities where manganese had been found and of the nature of such deposits.—"A supposed new mineral from the Du Toit's Pan Mine, Kimberley": W. **Versfeld**. The article consisted approximately of 71.5% of iron, 20% of silicon, and 8.5% of carbon. It was very refractory, and on crushing evolved an odour of acetylene. It was stated to have been found in the deepest levels of the Du Toit's Pan Mine.

Geological Society of South Africa.—Monday, August 28th: Dr. E. T. Mellor, F.G.S., President, in the chair.—"Note on some remarkable Xenoliths of altered shale from the Norite of Potgietersrust and Mapoch's country": A. L. **Hall** and C. **Gardthausen**. Shales belonging to the Pretoria series, invaded by the Bushveld magma, had undergone remarkable changes and lost all resemblance to the original shale. An interchange or transference of material had taken place, whereby entangled masses of shale—xenoliths—were intensely metamorphosed, more or less permeated with igneous material, and converted into rocks with highly abnormal mineralogical and chemical composition.—"Note on the Temnospondylous Stegocephalian *Rhinesuchus*": Dr. R. **Broom**. The characteristic features of two or three apparently nearly complete skeletons of a large Temnospondylous Stegocephalian found at Senekal, O.F.S., were briefly described. This Senekal *Rhinesuchus* differs from both *R. Whaitsi* and *R. Africanus* in being considerably larger. The author therefore proposes to call the new species *Rhinesuchus major*.—"On the remains of a Theropodous Dinosaur from the Northern Transvaal": Dr. R. **Broom**. A number of fragmentary bones of a Theropodous Dinosaur apparently allied to *Massospondylus* found on the farm Wiepe on the Limpopo had been described before the Society in June, 1907. As the result of increased knowledge of the structure of early types of Theropodous Dinosaurs, the author was now in a position to make a more precise determination of the Transvaal form. As it agreed more closely with *Gryponyx* than with *Massospondylus*, he proposed to place it provisionally under the former genus and to name it *Gryponyx transvaalensis*.—"On the occurrence of waterworn pebbles in the Lower Beaufort Shales": Dr. R. **Broom**. Most of the Lower Beaufort beds were shallow water and land deposits. In the stratified shales of the Lower Beaufort no fossil reptile had ever been found. In Lower Beaufort times what is now the Southern part of Africa was part of a flat desert through which a huge river flowed, spreading out into marshes and lakes about the centre of what is now the Cape Province. A number of waterworn pebbles were found by the author in the Moordenaars Karroo, and at Koornplaats there were great masses of silicified wood together with further waterworn stones. The latter had certainly been carried thither by the drift-wood, which it was almost certain had come from the north-east. The large river which transported this had flowed south-west in pre-Karroo times, almost in the line of the present Harts River, and had evidently continued on through the Carnarvon Division.

South African Institute of Engineers.—Saturday, September 9th: Mr. F. H. Davis, President, in the chair.—"The Prevention of dust in development drives of mines during drilling operations": C. J. N. **Jourdan**. A system was described for preventing the formation of dust by the removal of finely divided rock *débris* by means of a jet of water under a pressure of 40 to 80 lb. per square inch playing uninterruptedly into the hole where the formation of dust would otherwise be proceeding.

Chemical, Metallurgical and Mining Society of South Africa.—Saturday, September 16th: Mr. W. R. Dowling, Vice-President, in the chair.—"Notes on the use of certain cyanicides in the estimation of undissolved gold": H. A. **White.** In the treatment of slime by cyanide solution difficulty arises in securing an accurate estimate of undissolved gold. The method proposed depends on the fact that alkaline permanganate in excess destroys the power of .1% potassium cyanide to dissolve gold leaf.—"The assay of gold-bearing cyanide solutions by electrolysis": C. **Crichton.** The author described a method of depositing the gold electrolytically on a lead cathode, whence it is subsequently obtained by cupellation. The cathodes are made from ordinary assay lead-foil, and a native can, during a few hours, make enough for 200 to 300 assays. The anodes are 5-16th in. arc-lamp carbons. The apparatus consists of four oblong frames, each holding eight beakers with centrally clamped anodes. The solutions for assay are measured off in 10 A.T. portions, and in four hours the deposition of the gold is complete, the current being obtained from three two-volt accumulator cells charged from a direct current lighting circuit through a suitable lamp resistance.

South African Institute of Electrical Engineers.—Thursday, September 21st: J. H. Rider, V.P.I.E.E., President, in the chair.—"A comparison of costs between the Ward-Leonard and Three-phase winding systems": A. H. O. **Renner.** Assuming that the cost of the Ward-Leonard system is initially the higher, the author argued that this is largely counterbalanced by the difference in working costs, and he proceeded to discuss the influence of the higher cost due, in the Ward-Leonard system, to the motor generator set.

South African Society of Civil Engineers.—Wednesday, October 11th: Col. G. T. Nicholson, M.I.C.E., President, in the chair.—"Methods of construction and prime costs": Prof. A. E. **Snape.** Obervations on the sewage disposal works at Norwich and the main drainage works in London.

NEW BOOKS.

Hollis, Hon. A. C.—*Vocabulary of English words and sentences, translated into six languages or dialects, viz.: Zanzibar Swahili (Ki-Unguja), Mombasa Swahili (Ki-Mvita), Lamu Swahili (Ki-Amu), Patta-Swahili (Ki-Pate), Siyu Swahili (Ki-Siu), Bajun (Faza), Swahili (Ki-Tikuu).* [London] n.d. 8½ in × 5 in., pp. 24.

Kohlschutter, Dr. E.—*Ueber den Bau der Erdkruste in Deutsch-Ostafrika. Vorlaufige Mitteilung.* [Göttingen: 1911] 9½ in. × 7 in., pp. 40. Diagrams.

Madan, A. C.—*Living speech in Central and South Africa: an essay introductory to the study of the Bantu family of languages.* Oxford: Clarendon Press, 1911. 6s. nett.

Beech, M. W. H.—*The Suk: their language and folk lore.* With an introduction by Sir Charles Elliot. Oxford: Clarendon Press, 1911. pp. xxiv, 151. 24 plates, 3 maps. 12s. 6d. nett.

Dudgeon, G. C.—*The Agricultural and Forest products of British West Africa.* London: John Murray, 1911. pp. x, 170, 8vo. 18 oz., 5s.

A "FAUST" PROBLEM.

("*Faust*," *I*, 1335-1334.)

By Prof. WILLEM SYBRAND LOGEMAN, B.A., L.H.C.

Among the many hard nuts which Goethe has presented in his "Faust" to readers and commentators the passage indicated in the title of this paper is one of the hardest. That some commentators pass over these lines, or part of them, with no, or very brief, comment, as if the meaning was fairly clear and needed but little elucidation, and that others explain *obscurum per obscurius*—and even some of the greatest and best are here guilty of that fault—is but a proof that not every guide can always be trusted, and a fresh illustration of the well-known "quandoque dormitat Homerus."

Let me first recall the lines to my readers. I will give the passage first in the original and then as it is rendered in English by Mr. Bayard Taylor in his admirable translation.*

Mephistopheles having revealed himself as "des Pudels Kern" (the poodle's real core), Faust asks him:

Wer bist du denn?
Meph.: Ein Teil von jener Kraft,
Die stets das Böse will und stets das Gute schafft,
Faust: Was ist mit diesem Rätselwort gemeint?
Meph.: Ich bin der Geist der stets verneint!
Und das mit Recht; denn alles was entsteht
Ist werth dass es zu Grunde geht;
Drum besser wär's, dass nichts enstünde.
So ist denn alles was ihr Sünde.
Zerstörung Kurz das Böse nennt.
Mein eigentliches Element.

Or in English:

Faust: Who art thou?
Meph.: Part of that Power, not understood,
Which always wills the Bad, and always works the Good.
Faust.: What hidden sense in this enigma lies?
Meph.: I am the Spirit that Denies!
And justly so: for all things, from the Void
Called forth, deserve to be destroyed:
'Twere better, then, were naught created;
Thus, all which you as Sin have rated,
Destruction,—aught with Evil blent,—
That is my proper element.

It is my intention, in this short paper, first to quote what some of the most authoritative "Faust" commentators have said in elucidation of these lines, and to show by a short discussion the insufficiency of their explanations, and secondly, to attempt to put before you as briefly and as clearly as I can what I believe to be the sense of Mephisto's Rätselwort and of his own paraphrase of the same.

Two lines—or I might perhaps say one line and one word—demand such explanation; if we can feel sure that we understand

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them, all the rest drops, if I may so call it, into its right place without much effort on our part. What does Mephisto mean by saying that he is "ein Teil von jener Kraft die stets das Böse will und stets das Gute schafft?" That seems to be the first question to which we have to seek an answer. That the meaning is not clear, does not lie on the surface; that the answer is not so self-evident that he who runs may read, and that this obscurity is intended by Goethe, is proved by the fact that he represents Faust himself as puzzled by the "enigma," of which he asks a plainer statement. The other "nut for us to crack" is: how do the words spoken next by Mephisto contain an answer to Faust's "What do you mean by that?" and—if we look close into it—we find that the answer depends largely on the sense of "verneint."

Among the commentators whose explanations we will examine, Mr. Bayard Taylor cannot claim a place in the first rank. But (as I said a little while ago) his translation, which I have used, is on the whole a most excellent one, and his Notes will no doubt be consulted by all English readers who cannot understand the drama in the original, and to whom, consequently, the commentaries in German are closed books. I therefore begin by seeing what Mr. Taylor has to say.

> In declaring himself, first, to be part of that power "which always wills the Bad, and always works the Good," Mephistopheles is unexpectedly frank. His expression coincides exactly with the declaration of the Lord as to the service he is obliged to perform. In the passage which follows he is equally honest, and the line, "I am the Spirit that Denies," clearly (*sic.*) describes the part which he plays from beginning to end. He is the spirit of Negation, and his being exists through opposition to the positive truth, and order and beauty, which proceed from the never-ending creative energy of the Deity. . . . His irreverence and irony are not only a part of his nature, but they are further increased by the impotence of his efforts—which he freely admits in the following passages—to disturb the Divine system.

What—I feel inclined to ask—would Mr. Taylor say of an author who wrote one of those old-fashioned dramas in which virtue is the victim of the traditional villain, and the criminal is finally defeated, if that author—on the first occason that the villain enters upon the stage—put into his mouth words the sense of which may be summed up: "I am the villain, I always try to do evil; but—don't be afraid! it always comes out all right!" And yet, if we accept Mr. Taylor's elucidation, Goethe has on his conscience (artistic conscience) a blunder almost equally absurd. Mr. Taylor is one of those who look upon Mephisto's declaration that "he always wills the Bad" as an unexpected frankness, and upon the second part of the declaration, that he "always works the Good," as a confession of impotence.

Mr. Taylor does not stand alone in this; Mr. Boyesen,*

* Boyesen, "Commentary on Goethe's 'Faust,'" pp. 151 and following of his work "Goethe and Schiller." This generally excellent commentary (which every reader of "Faust" should consult) has been translated into German by Otfrid Mylius and published in Reclams Universal Bibliothek (Nos. 1521, 1522 for the price of 40 Pfennig (about 5d.), elegantly bound 80 Pfennig (about 9½d.).

whose observations we will quote next, also alludes to Mephisto's "frankness"; he differs, as we shall see, from Mr. Taylor inasmuch as, according to the latter's view, Mephisto is frank and speaks the truth, *himself believing what he says,* whilst, according to Boyesen, Mephisto does *not* believe in his own statement.

Before quoting Boyesen's comments, allow me to call your attention to the startling remark of Mr. Taylor that in the line "I am the Spirit that Denies" Mephisto *clearly* describes the part which he plays.

Let us now hear what Mr. Boyesen has to say of our passage.

> The self-characterization of Mephisto, which now follows, is perhaps the most difficult, as surely it is one of the profoundest passages in the whole drama.
>
> At first sight the extreme frankness of Mephisto's self-definition has an air almost of naivete; but, more closely considered, it argues rather the most refined subtlety. In the first place, would it not be very singular to represent the devil as so humbly convinced of the futility of all his destructive work, nay, of his very existence? The question then lies near. Does he himself believe in the correctness of his definition? Surely he does not. The positive truth, in this instance, is the result of two negatives: it is a devil (a negative existence) who speaks, and he speaks what he does not believe. He manifestly adapts his tactics with much shrewdness to Faust's state, representing himself as on the whole harmless, and at the same time giving his answer an appearance of fearless, decisive logic which must be very refreshing to the scholar who has so long been grappling in vain with these misty problems.

So far Mr. Boyesen. I notice with pleasure that he points out how "very singular" it would be "to represent the devil as so humbly convinced of the futility of all his destructive work," but must confess that I am startled by the idea that Mephisto says what he himself does not believe, and I cannot help adding that I am unable to find any meaning in Boyesen's sentence: "The positive truth, in this instance, is the result of two negatives: it is a devil (a negative existence) who speaks what he does not believe." That two negatives make an affirmative, or some statement to that effect, I have often heard, but that two negatives results in a positive truth is quite "another story." Besides, what is a "negative existence"? and what is the meaning of the theory here enunciated? I can scarcely think that my interpretation of Mr. Boyesen's words is the one he intends, but the only meaning I can find for them is the curious notion that a statement must be necessarily true if we can but imagine that a devil utters it without believing it.

Let us now listen to a few of the most authoritative among German commentators.

Düntzer, in his notes to the edition of "Faust" published in the well-known series Deutsche National Literatur (vol. xciii.), does not seem to think much explanation is needed. All he says is:

Der Teufel muss . . . wider Willen die Wahrheit gestehen. Das er das Böse wolle, wird, 984—1004 ausgeführt, aber nicht dass er das Gute schaffe.*

Here we have, then, a third theory: neither does Mephisto naively (stupidly or absurdly) "confess" the truth, nor does he speak the truth, believing that he is telling an untruth; according to Düntzer Mephisto confesses the truth "even against his will." Neither this, nor the statement that in what follows in the play one part of Mephisto's word is enlarged upon and another part is not, will, I fear, help us much in our search for enlightenment. It is evident that Düntzer either thought no explanation was needed or . . . . could not find an explanation to give.

Schröer† is another scholar of repute to whom we owe an edition of "Faust" containing much that is helpful and suggestive. But with regard to our passage he leaves us in as great a darkness as before: he says:—

S. 91 Die Erklärung dass er die Absichten Gottes fordern, das Gute schaffen helfe, obwohl er stets das Böse wolle, theilt den Kreislauf der Dinge zwischen Entstehn und Vergehn zwei entgegengesetzten Mächten zu, wobei die letztere, die das Vergehn bewirkt, als Böse bezeichnet wird, als Sphäre des Teufels. Dass er die Vernichtung selbst das Böse nennt und die Schöpfung das Gute, bekundet eine Einsicht weit über seine Grenze hinaus. Doch ist es bei ihm auch nur Phrase, die sich in seinen weiteren Reden widerlegt.‡

It seems evident by the last words that Schröer sides with those commentators who hold that Mephisto does not mean what he says, but I doubt whether the phrase "assigns all that lies between coming into existence and perishing to two opposite powers," etc., does much to elucidate Mephisto's words, whether these are honestly meant or not. But the most astonishing part of Schröer's comment is the sentence: "Das er die Vernichtung selbst das Böse nennt und die Schöpfung das Gute, bekundet eine Einsicht weit uber seine Grenze hinaus," which I have attempted to render by: "This he himself calls Destruction Evil and Creation Good shows an insight which far surpasses his limitations." I am far from feeling sure that I can grasp the meaning of the "Einsicht weit über seine Grenze hinaus." I do not know which "Grenze" is imagined here, nor why the "Einsicht" surpasses it. But that really does not matter, since

* The devil is forced . . . even against his will, to confess the truth. The statement that he "wills the Bad" is enlarged upon in lines 984—1004, not so the assertion that he "works the Good."

† Schröer: "Faust von Goethe." Mit Einleitung und fortlaufender Erklärung herausgegeben, von K.I. Schröer, Leipzig: O.R. Reisland, 1898.

‡ The declaration that he (Mephisto) assists in promoting God's intentions in "working the Good," notwithstanding the fact that he always "wills the Bad," assigns all that lies between coming into existence and perishing to two opposite powers, of which the latter—which "works the Bad"—is characterised as Evil, as the domain or sphere of the Devil. That he himself calls Destruction Evil, and Creation Good shows an insight which far surpasses his limitations. But even this is with him no more than a phrase (verbiage) which is confuted in what he says next.

it is all said about Mephisto calling Destruction Evil and Creation Good, which is exactly what Mephisto does *not* do! I hope to make this clear in the concluding part of my paper, when I submit my own interpretation to your judgment.

We have now heard what two foreigners (not Germans), Taylor and Boyesen, have said on our subject; we have next consulted two editions with annotations by Germans (Düntzer and Schröer); we will now conclude this part of my paper by listening to two famous commentaries, those of Minor* and Fischer†.

Minor says in vol. ii. of his extensive "Entstehungsgeschichte und Erklärung," on page 162 and following:—

Diese Selbstdefinition gibt zu zwei Bedenken Anlass: Zunächst scheint M. hier doch gar zu sehr ausser seiner Rolle zu stehen, sich abstrakt, philosophisch, theoretisch über sein eigenes Wesen auszulassen, also mehr Sprachrohr des Dichters als dramatischer Charakter zu sein; dieser Mangel ist offenbar vorhanden, . . . Zweitens fällt es auf, das der Lügengeist hier so gar nicht "englisch lispelt," seine Krallen gar nicht versteckt, sondern Faust, den er doch seine Strasse führen und für sich gewinnen will, seine teuflische Natur und seine bösen Absichten hochst aufrichtig und ausführlich enthüllt.

Mephisto nennt sich, ganz in Uebereinstimmung mit dem Prolog, einen Vertreter des bösen oder des verneinenden Prinzips. Dabei macht es keinen unterschied aus, wenn er sich hier als *den* Geist bezeichnet der verneint während er im Prolog bloss als *einer* der verneinenden Geister erscheint; denn auch hier nennt er sich umittelbar daneben einen blossen Teil, eine Unterscheidung, die er selber ironisch als eine bescheidene Redewendung im Gegensatz zu dem unbescheidenen, sich als Mikrokosmus fühlenden Menschen ausgibt. Er ist . . . der Pessimist dem nichts recht ist, dem alles Bestehende des Unterganges wert erscheint. Darum ist er auch der Geist der Zerstörung. . . . auch hier aber ist seine Tätigkeit eine ganz erfolglose. . . . Das Uebel ist auch hier bloss der Sauerteig des Guten und sogar der Teufel, der das Böse will, schafft wider seinen Willen, das Gute.

Or in English:—

This definition of himself evokes two criticisms: In the first place Mephisto does seem here to be in conflict with the character of the other parts of his role (lit., to stand too much outside his role), to be discussing his own Nature in an abstract, philosophic, theoretic manner; consequently he is here rather the poet's mouthpiece than a dramatic character; this blemish is undeniable. . . . Secondly, we are struck by the fact that the "Spirit of lies" does in no way hide his claws, and that—though he wishes to become Faust's guide and friend—he perfectly openly and fully reveals his wicked intentions.

In perfect agreement with the prologue Mephisto calls himself a representative of the evil or negative principle. In this it makes no difference that here calls himself *the* Spirit who Denies, whilst in the prologue he merely appears as *one of the* denying Spirits; for here he also calls himslf, in almost the same breath, a mere part. . .

Mephisto is the pessimist to whom nothing seems right, to whom everything that exists seems worthy of destruction. Therefore he is the Spirit of Destruction . . . , [but] here again his work is entirely unsuccessful. . . . Evil is here once more nothing but the leaven of Good, and even the Devil himself, who wills the Bad, works against his will the Good.

* "Goethes 'Faust': Entstehungsgeschichte und Erklärung," von I. Minor, vol. ii, S. 162. Stuttgard: Cotta, 1901.

† "Goethes 'Faust': Goethe-Schriften," von Kuno Fischer, vol. viii, S. 348. Heidelberg: Carl Winters Buchhandlung.

The parts of this piece of commentary most interesting to us are Minor's accusation against Goethe of having made Mephisto "his own (the author's) mouthpiece rather than a dramatic character" (a startling accusation, surely!), and the commentator's addition of the words "against his will" to Mephisto's statement about "working the Good." We also note that Minor adds those words as it were "in passing," evidently taking it as self-evident that he is entitled to do so.

And now, last but not least, we come to Kuno Fischer. In vol. iii. of his celebrated "Faust" commentary, pp. 348 *et seq.*, he says:—

> (1) Die erste Erklärung heisst:
>
> 'Ich bin ein Teil von jener Kraft,
> Die stets das Böse will und stets das Gute schafft.'
>
> Das gute besteht nur in der Ueberwindung der Uebel und des Bösen, die wirkliche Welt, da sie nicht perfekt sein kann, ist *perfektibel*, d. h. fortschreitend, entwickelungsfähig und entwickelungstätig; daher ist die wirkliche Welt unter allen möglichen die beste. In dieser Anschauungsweise besteht der Optimismus, welchen unter den Philosophen der Welt keiner tiefer durchdacht und besser ausgeführt hat als Leibniz. Der goethesche Mephistopeles bekennt sich an unserer Stelle als Teufel im Sinne des Optimismus, Faust aber ist von dieser Erklärung betroffen und getroffen: Was ist mit diesem Rätselwort gemeint.
>
> (2) Sogleich folgt die Zweite Erklärung, welche die erste zu Böden schlagt:
>
> "Ich bin der Geist der stets verneint! u. s. w."
>
> Diese Worte des Mephistopheles sind der scharfste Ausdruck des Pessimismus: das Nicht-sein der Welt wäre besser als ihr Dasein. Faust aber hat die Erklärung überhört, er brutet noch uber dem Rätsel der ersten; "Du nennstdich einen Teil und stehst doch ganz vor mir?"
>
> (3) Jetzt verschärft und verdunkelt Meph. noch mehr sein rätselhaftes Wesen; er wirft nicht bloss die erste Erklärung durch die zweite, sondern alle beide durch die dritte über den Haufen.

Or in English:—

> (1) The first declaration is—
>
> "(I am) part of that power
> Which always wills the Bad and always works the Good."

Fischer's commentary (it surely cannot be called explanation or elucidation!) is:—

> Good consists only in the overcoming of evils and of "the Bad"; the real world, as it cannot be perfect, is *perfectible*, *i.e.*, progressing, capable of development and aye developing; consequently the existing is the best of all possible worlds.

How all this is to be found in Mephisto's words, or how all this serves to make them clear, Fischer does not say, but that—in the commentator's opinion—all this is implied in the lines quoted seems evident from what he says next

> "This way of looking on the world constitutes Optimism, which no one among the philosophers of the world has thought out more fully and worked out more completely than Leibniz. Goethe's Mephisto professes himself in our passage as Devil in the sense of optimism ('Teufel im Sinne des Optimismus.') Faust is, however, astounded and struck by this declaration, and asks: 'what is the meaning of this enigma?'"

We are tempted to ask: What has Leibniz to do here, and what, for the purpose of explaining Mephisto's words, does it matter whether he was an optimist or not? and what is "sich bekennen als Teufel in Sinne des Optimismus"? I cannot help making Faust's words my own and asking, "Was ist mit diesem Rätselwort gemeint?"

But Mr. Fischer's power of astounding his reader is far from exhausted. He continues:

(2) There follows the second declaration, which strikes the first down to the ground ["zu Boden schlägt"].

"I am the Spirit . . . Element."

These words of Mephisto [says Mr. Fischer] are the most definite expression of pessimism: the non-existence of the world would be preferable to its existence. Faust, however, pays no attention to this statement (of Mephisto's); he is still brooding on the riddle of the first: You call yourself a part, "yet showst complete to me," or "yet you stand before me a thing complete."

This fiction that Faust does not listen to Mephisto's answer certainly helps us out of the difficulty which would otherwise present itself if we accepted Mr. Fischer's interpretation, *viz.*, that Faust does not at once demand an explanation of the contradiction. But is it conceivable that Goethe wishes us to believe that Faust asks, "What do you mean?" and then does not listen to the answer? And again, is it conceivable that Mephisto, having uttered an expression of optimism (which Goethe thought sufficiently obscure in its paradoxical wording to let Faust, a scholar, a man of culture and wide learning, ask, "What do you mean?" but in which Mr. Fischer evidently finds nothing to puzzle him) can, in answer to Faust's request for explanation, simply flatly contradict himself?

What follows in Mr. Fischer's commentary does, strictly speaking, not concern us here, as it refers to that question of "part or integer," and to Mephisto's utterances about his own origin, his being "part of the darkness which brought forth the light." Yet, we can scarcely avoid quoting some of it, because what is said by Fischer about the lines that follow bears indirectly on our passage, and further illustrates Fischer's amazing theory of contradictions in Mephisto's words, and of Faust's mental attitude in this conversation.

(3) Now [thus our commentator continues] Mephisto still further intensifies and obscures his enigmatic nature; not only does he overthrow his first declaration by his second, but he now upsets both by the third.

And after quoting and shortly discussing the next ten lines spoken by Mephisto, Mr. Fischer tells us that Faust's reply of three lines: "I see the plan thou art pursuing," etc., is "völlig unmotivirt" (completely unmotived). Is this because Faust's intellect has become confused by Mephisto's lack of logic? Far from it!

"It is not [so we are told] by what Mephisto has said that these words of Faust are 'motivirt' (motived), but by . . . that which he is now going to say (*sic!*) by his fourth and last declaration, which stands in the same relationship to the third as the second to the first, *i.e.*, mutually destructive!"

I wish here, as it were in parenthesis, to guard myself against misconception. I feel the need of reminding my hearers that the tone of mockery and of disrespect which I have felt justified in adopting when discussing this extraordinary comment on Goethe's masterpiece, or rather on that small part which we are here studying, does not in the least characterise correctly my opinion of Fischer's writings about Goethe in general, nor even of all the rest of his Faust commentary in particular. No one who will study what Fischer wrote on these subjects can possibly fail to learn much and to realise that he is listening to a master. It is, however, in this particular instance so evident, I think, that this master is caught napping, that it startles a reader by the very contrast with the other work. The nearer anyone stands to Homerus, the apter he is to raise a smile *quando dormitat*.

We might quote and refute still others of the many commentaries, but, it seems to me, enough has been said to prove (*a*) that authorities differ; (*b*) that the difficulty exists, is not imaginary; and (*c*) that in those comments that we have quoted the solution has not yet been found.

Allow me a few moments in which to suggest to you where that solution may lie.

First and foremost, it may have struck you that not one of the commentators clearly establishes the logical connection between the two utterances of Mephisto—nay, that one (Fischer) goes so far as to emphatically deny that such a connection exists; he says the one is the very contradiction of the other!

And yet, surely, if an intellect like Faust, in reply to one so sharp and witty as Mephisto, asks, "What do you mean?" it is clear (*a*) that the first saying is not so simple and clear that no especial thought, reflection or enquiry on our part is needed to grasp its meaning, and that such meaning does not lie on the surface. If to some commentators the words seem not to need explanation, Faust thinks otherwise. (*b*) That the answer to the request for explanation must contain that explanation or part of it; that the answer is, as it were, a commentary on the words to be explained. Now, a commentary, if it is a good one, must be easier to understand than the passage which it elucidates. *Ergo*, if we want to study both sayings of Mephisto, we shall do well to begin with his second utterance, and when we have fully investigated its sense, inquire what light this sheds on the saying which, in consequence of its intentionally paradoxical form, was so obscure.

Whatever may be thought of the explanation I have to offer, I am firmly convinced that none is admissible which makes Goethe commit a serious artistic blunder, and that none can be accepted which does not clearly show how the second saying explains the first. The very fact that Faust asks a further question about Mephisto's declaring himself "a part of that power" shows he is satisfied with what referred to the other part of the saying which he called an enigma.

I deem it, for our investigation, of such importance to gain a clear insight into what I would like to call the logical structure of our passage, that I must ask your patience for an imaginary conversation built on similar lines.

Let us suppose a man—thinking of what he has learned in his studies of the nature of light—utters the (intentionally obscure) paradox, "A green leaf is not green."

This is, of course, absolute nonsense if the words are, each of them, taken in their everyday meaning. We are prepared, when the other of the two speakers has asked for an explanation, to hear that—if these words do express a truth—one or more of them is used in a sense given to it for the nonce by the maker of the paradox. It will be found, when we have heard the explanation, that any paraphrase will almost unavoidably contain some such words as "what you call" and "what I call," etc.

The explanation being demanded, we suppose it is given in this form: First a general statement, which once more is not quite clear to the hearer, and which does not at once seem directly connected with the former: "White light or sunlight is nothing but a mixture of colours." This is followed by an explanation of the nature of light and of the fact that things are only seen because of their reflecting the light that falls on them, or part of that light. And this having been stated, the whole is then shown to contain the elucidation of the first paradox. The speaker continues in some such words as:

"So then, we see that the leaf which *you* call green only seems so to you because it absorbs all other colours and reflects only the green. It does not contain any green-colour producing substance; if any light that contains no green is thrown upon it, it will appear black; it is not what *I* called green, *i.e.*, it is not green of its own nature."

Now the scheme here illustrated is the one I believe exists in our passage. I will therefore first enquire into the meaning of, "Ich bin der Geist der stets verneint," and attempt to find an elucidation in the three lines that follow:

> Und das mit Recht; denn alles, was entsteht,
> Ist wert dass es zu Grunde geht;
> Drum besser wär's dass nichts entstünde."

These lines are in themselves so clear and plain that we need not spend time in commenting upon them, except in so far as to emphasise the fact that the words "und das mit Recht, denn" show beyond the possibility of doubt that they are intended to justify Mephisto's "*Verneinen.*" This verb has been translated by "to deny," and it seems to me that too close an adhesion to its first and more literal meaning of "to say no" has caused all the difficulty of such comments as the calling Mephisto "a negative existence," etc. But Mephisto says, "Ich verneine stets" (I am always "denying"), and I am right in doing so, because "all things from the Void called forth deserve to be destroyed." We ask then: What action that can possibly be indicated by "*verneinen*" does anyone that holds this pessimistic opinion consider justifiable and justified? "*Verneinen*" (to deny, to contradict) implies criticism and disapproval. Is the step from *criticising* and *disapproving* to "being in opposition" and "blaming that of which others approve," and then to "trying to destroy what is blamed," too great to suppose that even the latter, the wish for destruction of what is generally thought desirable, is more or less definitely implied *here* in the verb "verneinen"?

I am not one of those who ransack a writer's works for all instances of his use of any particular word, and then talk as if the meaning which the word has in one passage *proves* that, when it occurs elsewhere, it must necessarily have that same sense as before. But, if the meaning of a word as used by an author is not very clear, and the context suggests a somewhat far-fetched, but nevertheless possible, explanation, the probability of that interpretation being correct is brought near to certainty if we can show that the sense which we tentatively assign to the word is actually given to it by the author in a passage that does not leave any doubt. It is therefore in support of my translation or paraphrase of "verneinen" by "to oppose what others approve" and "to wish to destroy it" that I point out that Goethe himself speaks ("Aus meinem Leben," III., XI. Buch.. Reclam ausgabe, Bd. 24, Seite 26) of what we would call "destructive criticism" as "Kritik verneinend, herunterziehend," and (*ibid.*, p. 42) places "verneinend" and "zerstörend" as synonymous into close juxtaposition; similarly, in his article "Deutsche Sprache" ("Jenaische allgemeine Literaturzeitung," 1817), he speaks of "Verneinend, abrathend, widerstrebend zu werke gehen."

Thus, supported by Goethe himself, I think we may paraphrase (I do not say translate!) the four lines somewhat as follows: "I am the Spirit who is always in opposition, and always disapproving of what most people think right and good. I do what I can against the established order of things, and I consider that I am right in doing so, because, really, everything created is so bad that it ought to perish, and consequently I hold that it would be much better 'there were naught created.'" The three lines that follow offer no real difficulty. We must only point out that in Mr. Taylor's translation they are far from being as definite and as clearly expressed as in the original. Nay, one phrase which for our purpose is of great importance is, in the translation, if not, perhaps, quite wrongly rendered, certainly obscured. Let me recall to your memory Mephisto's very words in the original. Paraphrasing or much comment will be found unnecessary. A correct prose translation free from the trammels of rhyme and rythm will then suffice:—

> So ist denn alles was ihr Sünde,
> Zerstörung, kurz das Böse nennt,
> Mein eigentliches element.

I.e., "Ergo: all that you people call sin, destruction—in short, 'Evil'—is my element"; that is to say, "What you call evil is what I approve of and consider good."

If this conception of this second saying of Mephisto's is correct, and if you agree with me that we *must* take this reply as an elucidation of the initial paradox, "I always will the Bad, but always work the Good," I can find no other solution for the difficulty than this: Mephisto says: "I always am trying to do what you people call wickedness, sin, evil, but what really is good." In Mephisto's declaration Evil and Good are not, as all commentators take for granted, the names of two diametrically opposite principles, but two names for one and the same thing viewed from two diametrically opposite standpoints. I imagine the words "stets das Böse will" spoken by a good actor, if he adopt my interpretation, with just a faint sarcastic smile. That same actor would then lay a noticeable stress on the "ihr" in "was ihr Sunde nennt."

I think I may claim for this interpretation, *firstly*, that it saves us from the necessity of believing that Goethe has been guilty of an artistic blunder, a theory to which, as we have seen, some commentators find themselves driven. There is no imprudent frankness, there is no confession of impotence, there is no absurd inconsistency and self-contradiction in Mephisto's words; he does *not* call destruction evil, nor does he call creation good. *Secondly*, that it assigns to Mephisto's utterance a sense admirably adapted to Faust's character and mood.

Faust, the scholar who has studied all sciences and found none that satisfied his thirst for full and complete truth, and for that knowledge which would make him understand "the inmost force which binds the world, and guides its course,"—Faust, who has a few moments before Mephisto's appearance confessed to himself that he "does not pretend to aught worth knowing," is so thoroughly disgusted with the world in which he lives that "no dog would endure such a curst existence." Even magic has failed him when he sought its aid, and the Earth-spirit ("Erdgeist") whom he calls up has crushed him and taken away all his self-confidence, which the sight of the sign of the macrocosm had momentarily inspired. "A thunderword hath swept me from my stand," he says, and, thoroughly disheartened, he thinks of committing suicide. True, a reminiscence of childhood has made him put down the poison, but even this milder mood soon passes away once more, when the gratitude of the peasants on Easter morning reminds him how his father and he himself vainly strove against disease and plague, and he reproaches himself with pretentious ignorance and sighs: "I must hear, by all the living, the shameless murderers praised." So "two souls, alas! reside within (his) breast"; the "one with tenacious organs holds . . . the world in its embraces," the other "strongly rises away from this dust into higher spheres."

When next we find him in his study, he is for a while longer under the sway of the "Easter-mood," but no sooner does he resume his meditations than we hear him say: "But, ah! I feel . . . contentment flows from my breast no longer," and when he makes an attempt to find consolation in the New Testament, the first and only result is criticism, doubt, and an interpretation which in reality is a flat contradiction.

To this doubting, despairing, disgusted, though still vaccilaing mind, Mephisto presents himself, not with the information, "I am an impotent evil Spirit," but with words that chime in with Faust's pessimistic mood: "I (like you) am disgusted with this world; in fact, I think it fully deserves complete destruction. I like to do all I can to counteract its usual processes. Many people call this evil, but I maintain that that is good."

Can we, I ask, have a better opening of a conversation the aim and final result of which is Mephisto's proposal that Faust, who is miserable because until now he has tried what others and he himself have been accustomed to call Good, shall now try to find happiness in what Mephisto teaches him to call Good?

In conclusion, one more remark: it might at first sight seem possible to interpret Faust's question, "Was ist mit diesem Rätselwort gemeint," as referring merely to the first words of Mephisto's, "Ein Teil von jener Kraft," and one commentator seems to accept this view. But I firmly hold that this cannot have been Goethes intention, because, first, Mephisto—who after all is a supernatural being, and shows an intimate knowledge of what has been in Faust's mind—must be taken to know what Faust means by his question; and, secondly, because Faust listens attentively to what Mephisto says in elucidation of the words "der stets das Böse will," etc., and neither interrupts him nor, when he has finished, says anything like: "Yes, I see that, but I asked, 'What do you mean by 'ein Teil von jener Kraft?'" Faust *does* want to know that *also*, but he does in no way speak as if it was the only point he thought obscure.

Grants for Research.—As a result of the recommendations recently made by the joint committee of this Association and the Royal Society of South Africa (vide p. 66, *ante*), a General Committee has been constituted on the lines already indicated, and held its first meeting a few weeks ago, for the purpose of considering applications for grants which had been received. Five grants, amounting in all to £250, were made, and were comprised as follows:—(1) £40 to Prof. W. A. D. Rudge, M.A., of Grey University College, Bloemfontein, for the purpose of obtaining a continuous record of the variations in the atmospheric gradient at various places, and of ascertaining the relation between potential gradient and altitude, and between the diurnal variation of the gradient and the variation in the atmospheric pressure; (2) £45 to Prof. A. Young, M.A., B.Sc., of the South African College, Cape Town, for the purpose of investigating the occurrence of semi-diurnal, diurnal, and spring and neap tides observed by the applicant in connection with an artesian well in the Cradock District; (3) £75 to Miss D. F. Bleek, of Charlton House, Mowbray, for the purpose of proceeding to the Kalahari, so as to obtain phonographic records of the spoken language of the Bushmen tribes north of the Orange and Vaal Rivers, and to procure ethnologically interesting photographs and curios; (4) £50 to Mr. R. N. Hall, F.R.G.S., of Bulawayo, for the purpose of enabling the applicant to visit remote localities in Rhodesia, where Bushman paintings exist, so as to add to the list of paintings already discovered, and described, photographed, or sketched; (5) £40 to Mr. W. T. Saxton, M.A., F.L.S., of the South African College, Cape Town, for the purpose of (a) studying the fungus diseases of trees in the Transkeian forests, especially those diseases which appear sufficiently severe to be of economic importance, (b) investigating the œcology of the typical formations of the Transkeian territory, (c) investigating, in detail, a reported occurrence of the typical Western Province flora at St. John's, and (d) to collect material for the study of the two genera of South African Cycads, *Stangeria* and *Encephalartos*, by Prof. Chamberlain, of Chicago University.

Atomic Structure of the Elements. — At the recent Session of the British Association, Dr. J. W. Nicholson, dealing with theoretic determination of atomic weights, suggested that all elementary atoms may be built up from four protyles, containing 2, 3, 4, and 5 electrons respectively, in a volume distribution of positive electricity. Considering coronium, hydrogen, nebulium, and protofluorine as the four protyles, Dr. Nicholson deduced that the helium atom might be made up of one atom of nebulium and one of protofluorine. An argon atom would similarly be made up of ten helium atoms; a neon atom would consist of twice the combination $(PfH)_3$; an atom of xenon would correspond to $5\ [He_4(PfH)_3]$, and one of krypton to $5\ [Nu_4(PfH)_3]$, the symbols Pf and Nu representing respectively protofluorine and nebulium.

THE ORIGIN OF VERTEBRATES.

By William Hammond Tooke.

The fascination which such subjects as the origin of species and races, and their subsequent development, have exerted on the mind of the writer, must be his excuse for venturing into somewhat unaccustomed fields, and for the endeavour to place before those in South Africa, who take an interest in these matters, a remarkable theory which for some years has been propounded and defended by a biologist of repute*, but which, perhaps, has even yet not become as widely known as it deserves, whether as a genuine contribution to scientific knowledge, or as a masterly display of instructed dialectic. If the imperfect sketch attempted in this paper should attract the attention of those better qualified than himself to appraise and appreciate Dr. Gaskell's theory, the object of the present writer will have been attained.

The volume in which Dr. Gaskell's views are set forth and expounded is introduced by a quotation from a private letter, addressed by the late Professor Huxley to the author in 1889, as follows:—

"Go on and prosper; there is nothing so useful in Science as one of those earthquake hypotheses which oblige one to face the possibility that the solidest-looking structures may collapse."

The hypothesis, the enunciation of which constitutes the substance of this work, is certainly daring, if not earth-shaking. But, in order to consider it we must place before us the doctrine of evolution, or descent with relation to organic life, which the recent centenary of Darwin must have made familiar to all. According to the text-books it is this: That animals and plants now existing (for we shall not venture into the inorganic world) arose by a natural evolution from simpler pre-existing forms of life; those from still simpler, and so on back to a simplicity of life such as that now represented by the very lowest organism.†

Dr. Gaskell's position, in a few words, is as follows: The evolution of animal life is a process of upward progress, culminating in the highest form—man; and toward this upward progress the most essential organ, or group of organs, is the nervous system, or brain. Or, as he sums it up at the end of the volume:—

"The law for the whole animal kingdom is the same as that for the individual; success in this world depends upon brain."

In the original cœlenterate stock‡ this central nervous system naturally centred and clustered round that most important

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* "The Origin of Vertebrates," by Walter Holbrook Gaskell, pp. x., 538. London: 1908 (Longmans, Green and Co.).

† Thomson, "Outlines of Zoology," chap. vi.

‡ Cœlenterata or Radiata = sea-anemones, jelly-fish, etc.

organ of assimilation and growth, the mouth, or opening of the digestive cavity; for the primitive cœlenteron was little more than a food-bag.

So in the higher animals—in the annelids, or worms, we find a dorsal central ganglion; that is, a nerve mass, in the upper part of the head, and a ventral gangliated chain extending on the underside throughout the length of the animal; in the arthropods, a central dorsal ganglion, referred to in this work as "supra-œsophageal," or above the gullet, and an "infra-œsophageal" ganglion. Between these two ganglia in the head of the arthropod lies the stomach, called, from its position in the head, the "cephalic stomach." "Arthropods," it may, perhaps, be explained, is the name given to the large order which includes crustacea (lobsters, crabs, king-crabs, etc.), scorpions, spiders, and insects.

The continual expansion and development of the nervous system consequent upon evolutionary progress leads to pressure upon the digestive organs which it surrounds; and the arthropod animal finds itself faced with an increasingly perplexing problem. The development of the brain is necessary to enable it to adapt itself to its environment; but the stomach and dependent digestive organs cannot well be dispensed with if the animal is to repair the bodily waste and carry out its functions.

It would seem, however, that the nervous and digestive systems which should have been mutually helpful, were, by the exigencies of space in the head and thorax, thrown into a position of antagonism; it became a question of fighting for "head-room"; and, in the struggle that must apparently have ensued, victory or defeat would have been equally fatal to the perpetuation of life in this class of organisms.

"Something had to be done [says Dr. Gaskell]. Some way had to be found out of this difficulty."

The situation certainly seems extraordinary! But the way out suggested by our author is not less remarkable. It is as if an All-Wise Providence had said: "Bless me! I am working on wrong lines altogether! I must make another try!" But this fresh "start" entailed a radical change in design; for the threatened atrophy of the brain

"meant degeneration and reduction to a lower state of organization; while on the other hand the further development of the brain necessitated the establishment of a new method of alimentation or feeding."*

Lamartine describes how the great Architect of the Universe

"D'un pied dédaigneux le lançant, dans l'espace,
Rentra dans son repos."

But, if Dr. Gaskell's hypothesis is accepted, it is plain that that attitude has to be abandoned in order to prevent a break-down.

* *Op. cit.*, p. 57.

After this marvellous self-working, self-maintaining machinery of life had worked successfully through the various geological epochs, from the Cambrian to the Cretaceous Age, it was found to be contrived on a faulty plan, and had to be amended by the simple expedient of throwing overboard the digestive apparatus which had hitherto grown and developed around the mouth of every animal from the coral to the crab, while the Creator corrected His creative work by constructing and substituting an entirely new apparatus with all the latest improvements.

This, by way of analogy. Dr. Gaskell does not, of course, burden his thesis with any arguments either for or against the creation, or any other origin of the universe. He is only concerned with this planet, and only with life on this planet since the palæozoic era. The point is that, according to his view, somewhere between the highest non-chordate and lowest chordate there arose, in the steady progress of evolution, some sort of crisis, or we might even say catastrophe.

On the face of it one is naturally unwilling to accept any theory involving a breach in what we call the law of continuity of design. It offends the innate instinct towards unity which comprises a portion of our mental equipment. But, what is, perhaps, a graver objection to Dr. Gaskell's theory is, that it runs counter to what has been considered as a fundamental axiom among geologists.

The tissue of the original primitive cell consists of three layers—the outer layer or epiblast, the inner layer or hypoblast, and the intermediate tissue or mesoblast, though this is not represented in the classes ranked below the annelids, *i.e.*, sponges, cœlenterata, etc. In the higher animals the nervous system and sense-organs are evolved from the epiblast or ectoderm; the gut and its outgrowths, lungs, liver, etc., from the endoderm or hypoblast; the skeleton, muscles, etc., from the mesoderm or mesoblast. Now, Dr. Gaskell commits the heresy of evolving the vertebrate gut from the arthropod nervous system; that is, he derives the gut from an epiblast, instead of from a hypoblast; or, as he puts it, the epiblast of the arthropod may become the hypoblast of the vertebrate, and *vice versa*.

Needless to say, we shall not attempt to decide where doctors disagree; but we may, perhaps, be permitted to glance at some of Dr. Gaskell's arguments.

The general design in the construction of vertebrates is so radically different from that of invertebrates that zoologists and anatomists, although easily tracing the line from protozoa through corals, zoophytes, etc., to worms, starfish, crustaceans and insects, and while, with even greater ease, finding the ancestors of the mammals and birds in reptiles, amphibians and fish-like animals, the remains of which have been discovered in geological strata, have yet found the gulf between the highest form of crayfish or scorpion, annelid or mollusc, and the lowest vertebrate form well-nigh impassable.

This may, perhaps, be owing to the imperfection of the geological record; but scientists have for some time endeavoured to trace some line of descent between some annelid, like the earthworm or lobworm, on the one hand, and the unique balanoglossus or lancelet on the other; the latter being regarded as a primitive ancestor or degenerate descendant of a fish, the former rather doubtfully ranked as an archaic vertebrate on account of its being the happy possessor of a rather questionable notochord. Another attempt ,through a different channel, connects the molluscoid lampshell with the tunicate or sea-squirt, whose larval form also boasts a notochord "in the tail!"

These theories between them may be said to have held the field until Dr. Gaskell's "earthquaking hypothesis" effected a linking up of the broken chain in the persons of two solitary survivors of their respective families, the king-crab and the lamprey, by the simple process, as already explained, of converting the gastric system of the arthropod into the brain ventricles of the fish, which obligingly constructs for itself, *proprio motu*, a fresh digestive system out of a portion of its respiratory apparatus.

In spite of its revolutionary character, Dr. Gaskell's contention is supported by two considerations: First, the extreme probability, on quite other grounds, that some such metamorphosis actually took place at a time when the arthropods were at their greatest period of development, since it coincides with the first recorded appearance of representatives of the class Pisces in form greatly resembling in some respects the king-crab, in others, the hagfish or lamprey. Secondly, that such a fundamental alteration can be regarded as a parallel, if not a precedent, to the change which undoubtedly must have taken place when marine vertebrate organisms first developed into amphibious and land-frequenting animals; a change not, perhaps, so drastic, nor involving the heretical conversion of hypoblast into epiblast, but still entailing nothing less than the transformation of the air-bladder of the fish into the lung of the amphibian, and the atrophy of the gills, or their employment in other than respiratory functions.

Says Dr. Gaskell:—

"This transition from the gill-bearing to the lung-bearing vertebrates is most interesting, for it has been proved that the lungs are formed by the modification of the swim-bladder of fishes; and in a group of fishes, the Dipnoi, or lung-fishes, of which three representatives still exist on earth, the mode of transition from the fish to the amphibian is plainly visible; for they possess both lungs and gills, and yet are not amphibians but true fishes. But for the fortunate existence of Ceratodus in Australia, Lepidosiren in South America, and Protopteris in Africa, it would have been impossible from the fossil remains to have asserted that any fish existed which possessed at the same moment of time the two kinds of respiratory organs, although from our knowledge of the amphibian we might have felt sure that such a transitional state must have existed."

The foregoing has been brought forward by Dr. Gaskell, not, of course, as his own discovery, as it is a commonplace of all the text-books, but as an argument by analogy in favour of the possibility of the original vertebrate having acquired his new digestive outfit before the old one was absolutely functionless in that respect, and having thus tided over a very precarious period when it would have been very risky to have been off with the old love before he was on with the new.

The preceding argument, based upon the first appearance of the vertebrate in geologic time, is set forth by Dr. Gaskell as follows:—

"Before the highest mammal—man—appeared, the dominant race was the mammalian quadruped, from whom the highest mammal of all—man—sprung; then comes in Mesozoic times the age of reptiles, which were dominant when the mammal arose before them. Preceding this era we find in Carboniferous times that the amphibian was dominant, and from them the next higher group, the reptiles, arose. Below the Carboniferous comes the Devonian strata with their evidence of the dominance of fishes, whence the amphibian was directly evolved. The evidence is so clear that each succeeding higher form of vertebrate arose from the highest stage reached at the time as to compel us to the conclusion that the fishes arose from the race which was dominant at the time when fishes first appeared. This brings us to the Silurian age, in which the evidence of the rocks points unmistakably to the sea-scorpions (giant monsters, some six feet long), king-crabs and trilobites as being the dominant race. It was preceded by the great trilobite age, and the whole period from the first appearance of the trilobite to the dwindling away of the sea-scorpion may be designated as the Palæostracan age, the term Palæostraca to include both trilobites and the higher scorpion and king-crab forms evolved from them.

"The evidence of geology thus points strongly to the origin of the vertebrates from the Palæostraca arthropod forms which were not crustaceans and not arachnids,* but gave origin both to the modern day crustaceans and arachnids."

Dr. A. S. Woodward, who, in his address before the British Association,† alludes to this passage in Dr. Gaskell's book, points out that the true fish of the Devonian age had, most of them, paddles which they used as crawlers as well as swimmers, differing in this respect from the typical fish. Moreover, as Dr. Gaskell shows, these fishes—*Pteraspis*, *Cephalaspis*, *Pterichthys*—resemble, in a remarkable manner, members of the Palæostracan group—*Eurypterus*, *Hemiaspis*, *Phrynus*—so that it is difficult to decide whether a fossil of which the softer parts had disappeared, was a fish with a head-shield, or an arthropod with a carapace.

Again,

"fortunately there is still alive on this earth one member of this remarkable group (of arthropods), the Limulus or King-crab. On the vertebrate side the lowest non-degenerate vertebrate is the lamprey which spends a large portion of its existence in a larval stage. The value of this fact will be seen."

The bulk of the work is too technical for the layman, although the information afforded by the excellent illustrations

* Arachnids = scorpions, spiders, etc.
† At Winnepeg.

that adorn the book do much to help one to realise, by means of comparison, both the resemblances and the differences which appear respectively in analogous and in homologous organs of the selected representatives of the arthropod and chordate phyla. From these one can gather with intense interest how Dr. Gaskell seeks to establish a case which is certainly much stronger than anyone could have anticipated from a cursory view of the position.

Thus, assuming that the original cephalic stomach had ceased, or would shortly cease, to perform its functions, he shows how the nervous ganglia which constituted the brain extended round it until it converted itself into what was merely the third ventricle; while the spinal marrow built itself round the original alimentary canal, and the gullet became a closed sac or slight invagination of the brain (fundibulum).

This involves the proposition that a new gut or alimentary canal had to be formed. This, the author admits, appears at first sight too great an assumption to make, but justifies it by a comparison of what takes place (as already shown) in the lung-fish when it uses its swim-bladder as a lung, and allows its gills to become functionless. The new alimentary system, Dr. Gaskell explains, is constructed out of a portion of the old breathing apparatus.

The fact that the pineal or median eye, existing and functional in the arthropods of the Silurian age, is found present in the larval lamprey, while in the adult it is superseded by functional lateral eyes, the normal eyes of the vertebrate, is very significant, as also the presence in the vertebrate eye only of the characteristic Mullerian fibres which are not found in invertebrates, but which Dr. Gaskell traces back to a process in the alimentary canal. He asserts that the segmental excretory organs of the arthropods have become respectively converted into the pituitary gland, the tonsils, the thyroid, the thymus and the glands of the lymphatic system; the thyroid gland, in particular, he identifies very convincingly with the arthropoid generative organs.

The vertebrate heart he considers to have been evolved from the junction of two venous channels in the lower (ventral) part of the body, while the invertebrate dorsal heart has become functionless and atrophied, and exists as a mere mass of fat above the spinal cord in the larval lamprey, disappearing altogether in the higher vertebrates.

The relationship between the respiratory muscles of the arthropod and vertebrate appear to the layman obscure, and Dr. Gaskell's explanations appear to require a professional knowledge of anatomy and histology to be understood thoroughly. The olfactory organs, however, are traced clearly from their position in the scorpion to their subsequent situation in the lamprey—an instance where the organ and its function remain identical, but its position is changed; the converse of most cases of alteration. The author claims to have discovered in the king-crab a large auditory sense-organ akin to the pecten of the scorpions, which is the original of the vertebrate auditory apparatus.

The history is carefully followed of the legs and other appendages, the leg-jaws and masticatory apparatus of the king-crab and sea-scorpion; and the author shows apparently conclusively that they have been metamorphosed into the tentacles and upper and lower lips which surround the mouth of the larval lamprey. In the case of the Silurian fishes, such as the *Pterichthys*, he demonstrates that they have followed a different line of development in the paddles, or flappers, of the Ganoid fishes.

Dr. Gaskell points out also the likelihood that some of the earlier Silurian fishes were, not only without the usual jaws characteristic of the vertebrate skull, but were, on the other hand, provided with appendages less developed, perhaps, but resembling the legs and leg-jaws (endognaths and ectognaths) of the arthropods, thus constituting an important link between the arthropoda and vertebrata. Furthermore, the head-shields of the Silurian and Devonian fishes, *Pteraspis*, *Cyathaspis*, etc., not only greatly resemble the carapace of some of the arthropods, but are composed of muco-cartilage like the muco-cartilaginous head-shield of the larval lamprey, and not of bone, as is usual in vertebrate skeletons.

The cartilaginous skeleton of the larval lamprey, it may be said, is entirely different in substance from the bony skeleton of the vertebrate, while it is very similar to that of the king-crab, and presumably to that of the fossil forms.

In other respects it is shown that the difference is greater between the larval lamprey (*ammocœtes*) and the adult form (*petromyzon*) than it is between the king-crab (*limulus*), or sea-scorpion (*eurypterus*) and *ammocœtes*.

Indeed, the most remarkable feature in the whole history of this singular development is that the final stages of the metamorphosis are accomplished, not in the transition from one allied species to another—not even in the issue of the earliest and most primitive vertebrate from the latest highly developed invertebrate—by what might almost be called the normal process of fertilisation, gestation and birth, but in the lifetime, and by the metamorphosis, of the individuals of closely allied species, or varieties, during the short period that was requisite in order to complete the growth or transformation from larva to adult.

Were it not for the support afforded by this singular fact, constituting, perhaps, Dr. Gaskell's strongest argument, it would be difficult to accept his explanation of the formation of the vertebrate mid-gut, and its introduction between the original cephalic and thoracic region (pro- and meso- soma) and the original cloacal region (meta-soma). For it evidently owes its inspiration to the necessity of increasing the length of the body when the legs of the arthropod have disappeared, in order to furnish either a rudder-like tail, or loco-motor hind-limbs, for the purpose of providing fresh means of locomotion. Without such members the incipient vertebrate would fall back in the scale of being behind the whelk and the oyster, and become nothing better than a miserable sea-squirt!

In January and February, 1910, the Linnean Society held a debate, or discussion, on Dr. Gaskell's theory, which occupied two meetings of that body, during which it was considered from the standpoints of embryology, comparative anatomy, palæontology, physiology, and even psychology. The speakers were Prof. MacBride, Prof. Starling, Mr. Goodrich, Dr. Smith Woodward, Prof. Dendy, Sir Ray Lankester, Dr. Chalmers Mitchell, Rev. Mr. Stebbing, Dr. D. H. Scott, Dr. Gadow, and Prof. Stanley Gardner. The last two largely supported Dr. Gaskell's theory, but, speaking generally, although no counter theory was definitely put forward, the meeting, as a whole, was unable to accept that scientist's views, although those present expressed, through Sir Ray Lankester, their appreciation of his observations. Dr. Gadow strongly supported Dr. Gaskell in rejecting *amphioxus* as a lineal ancestor, a theory advocated by Mr. Goodrich, who held that there would be no difficulty in deriving the lamprey, or *ammocœtes*, from an *amphioxus*-like ancestor by a normal process of evolution in which cephalisation would take a leading part; but, as to what preceded the *amphioxus*-like ancestor, zoologists refused to commit themselves to an opinion. Prof. Starling's objection to Dr. Gaskell's theory was opposed by Dr. Smith Woodward. Generally, it appeared that, although the majority were sceptical, they were so for different reasons, and that the objections which appeared vital in the opinion of one, did not appeal with any force to the other.*

But when all is said and explained, is this theory, taken at its fullest, more difficult to accept or understand than the well-known facts of the metamorphosis of the tadpole into the frog, the axolotl into the salamander, the leptocephalus into the eel? Are the changes any more startling than those that take place in the pupæ of the lepidoptera?

* See "Nature," No. 2102, Vol. LXXXII, p. 445.

ON TRUE REPRESENTATION BY THE TRANSFERABLE VOTE AND WHAT IT WOULD DO FOR SOUTHERN RHODESIA.

By John Brown, M.D., C.M., F.R.C.S., L.R.C.S.E.

Synopsis.

1. What the transferable vote is, and how it makes every vote effective.
2. Examples of the present system where only 17 and 15 per cent. were effective.
3. A majority of non-effective votes is inevitable with majority election.
4. Unsatisfactory results of present system in the British Parliament.
5. Sectional election gives with the transferable vote true representation.
6. It is possible with three members, and works better with seven.
7. It works well at Pretoria, and is needed in Rhodesia.
8. With it all the possible effective votes are equally distributed.
9. In Tasmania and the Transvaal 99 per cent. are actually used.
10. The voters part, and the returning officers work.
11. Two rules to ensure absolute arithmetical precision in counting.
12. Comparison with present Rhodesian elections.
13. Need for special facilities for the rural voter, when you have made every possible vote effective.
14. How effective voting affects the voter.
15. Adaptability of the transferable vote. Needs of the rural voter.
16. Effective voting increases the number of voters, and their political interest.
17. By making canvassing impossible it increases the supply of the best candidates, and to some extent substitutes merit for ability to pay election expenses as the first qualification.
18. It makes the elected Member the Representative of the people, and in every way the equal of the nominated members.
19. It benefits the country, for in one large constituency each voter can vote where he happens to be working; every grade of difference of opinion can be expressed. We get one voter one vote, one vote one value, an equal number of votes for each member, and all votes effective.
20. It settles for the future the question of redistribution.
21. Additional representation becomes automatic.
22. A satisfactory solution of the question of bye-elections is afforded.
23. Recapitulation.

1. With the transferable vote the voter, instead of marking as now a cross × opposite the name of the man he votes for, marks in the order of his preference for them, with the numerals 1, 2, 3, 4, the four or more candidates, whom he thinks the best. If the returning officer finds that the man marked 1 is already elected, and therefore does not need the vote, he transfers it to the candidate marked highest on that voting paper, who does need it to help him in his election. He does exactly the same if he finds the man marked highest turns out to be an unsuccessful candidate. He thus makes use of every vote that can possibly become effective, that is, that can possibly help to return a member. We get every possible vote used, giving us true representation of all the voters; and any section of them numerous enough to elect a Member can secure representation. We have sectional election in place of our present system of relative majority election.

2. I would ask the reader to consider two actual cases of election under our present system. In one in Cape Town there were two candidates; the successful one got 1,695 votes, his opponent 296. One more than 296, that is, 297 votes, secured the member's return, were effective votes, helped to elect him; and the surplus 1,398 votes had nothing to do with electing him: they were non-effective votes, just as were his opponent's 296. Less than 15 per cent. were effective, more than 85 per cent. were non-effective; and it is these 85 per cent. of votes which the transferable vote enables us to use in securing through sectional election true representation.

The second case is that of the last Midland Division election at Gwelo. Colonel Heyman got 392 votes, the next candidate, Mr. Gilfillan, got 116. In this case the effective votes were 117; out of the 686 votes given for the four candidates, just 17 per cent. were effective, 83 per cent. were in this case non-effective; 166 votes out of every two hundred were non-effective.

With the transferable vote all these 569 votes would be used, to give some other candidate his quota—that is, the minimum number of votes, that will ensure his election, if it were possible so to use them.

3. Note please, that in every case of election where the majority exceeds two, or where a third candidate gets two votes, majority election necessitates a majority of non-effective votes. Say with 50 voters, one candidate gets 27, the other 23, the effective votes are 24, the non-effective, 26. With an odd number, 51 voters, say, the candidates get respectively 27 and 24, the non-effective votes are 26. These are the most favourable cases possible, where the election is with an absolute majority. In the two actual cases we have considered, under the British system of a relative majority, we found the non-effective votes were 85 and 83 per cent.

This fault, the large number of non-effective votes, is inevitable in this system of single member constituencies; it always will and must occur. We are using a wrong method of election, a method which only shows in each constituency which of two candidates the majority prefers, which necessitates in all cases that the minority shall be unrepresented, and which sometimes reduces the number of effective votes to a very small percentage. It utterly fails to secure true representation.

4. The Report of the Royal Commission on Electoral Systems, 1910, Cd. 5163, says of the seven British Parliamentary elections from 1885 to 1910: "Only in one case, the election of 1892, can the actual results be said to represent approximately the balance of voting power possessed by the two parties. If these conclusions are checked by the figures for contested elections only, they are merely confirmed. In the contested elections of 1895, a Conservative majority of 77 was returned by a minority of 25,000 voters. In England in 1906, an unusually cogent example, because out of 465 seats only 20 were uncontested, a Liberal majority of 200 members was returned by a margin of voting strength, which only warranted a majority of 55."

5. With majority election we never can get true representation. For that we must take another method, in place of trying to find in seven single-member constituencies which man of two each voter thought the better man, which man was most preferred; we must in three-member or larger constituencies try to find which man most of the voters prefer. We must in large constituencies, with numerous candidates, allow the voter to mark his preference for the four or more best candidates in his judgment; so that, if the first man of his choice does not need his vote, or cannot use it to secure his election, it may not be wasted or non-effective as now, but may help in the election of the highest placed candidate of his choice, who needs it. We must substitute for majority election sectional election, and for this we need the transferable vote.

6. We have just seen that in the election of one member, a section of the voters equal to one less than half can give only non-effective votes, cannot secure representation; so also, if two members are to be elected, a section of two less than one-third of the voters must give non-effective votes. But while a minority can never elect a single member, nor one of two members, it can elect one of three members, if it amounts to one more than one-fourth of the voters; and with constituencies electing three or more members Sectional election becomes possible, and the larger the number of members to be elected the better does it work. Thus in a three-member constituency the voters can give expression to their views on an important question by electing three members, if they are still of one mind; or two members on one side and one on the other. But in a seven-member constituency a much more varied expression of their feelings may be given, according to the voting strength on one side or the other. Their decisions may vary from 7 to 0, through

6 to 1, 5 to 2, *i.e.*, down to 1 to 6 or 0 to 7: in stages or degrees varying by one-seventh of the voters.

7. Sectional election may seem more difficult and too complicated. It may be thought, it is all very well in theory, but in practice it could not be done. Two years ago at Pretoria it was tried for the first time; 2,814 votes were given for 13 candidates to elect 6 members. If each of the 6 members got 403 votes, that would be 2,418, leaving only 396 over, not enough to give that number, 403, to a seventh candidate. The votes that were actually given to the six members were 2,382, just 36 less than the utmost possible number of votes that could become effective. Only 36 votes that might have been effective were non-effective, .015 or three two-hundredths, three votes in 200, compared, as we saw at Gwelo, to 166 in 200.

It is the system that is at fault, not the voter. It would be a scandal and an untruth to say the Rhodesian voter was less intelligent than the Pretoria municipal elector. The voters in Rhodesia are as intelligent as you will find anywhere, and they would need to be, for their circumstances are peculiar. They are in a land where the British South Africa Company have spent millions of pounds directly and indirectly in obtaining and developing the country, without as yet one single halfpenny of return in the way of dividend. At one side of the Council table sit five members nominated by the Company, and at the other side seven members elected by the people; and these seven should be the very best men in all the land, not necessarily the richest, but the very best; they should not be elected by 17 per cent. of the voters, but by all as far as possible. The interests of the people and those of the Company are identical, and it is absolutely necessary that the people should have true representation, and the very best seven men they can elect. Think of the increase of power behind them if 99 per cent., not 17 per cent., of the voters elected them.

8. This result, 99 per cent. of the possible effective votes, will be got by substituting sectional for majority election; under it each seventh equal section of the voters elects a member by the same number of votes, who represents that section. In this way we can make use of nearly every possible effective vote. No system can make use of voting papers, whereon not one is marked of the names of the candidates, whom 99 per cent. of the possibly effective voters think the best. In Rhodesia these cases should be conspicuous by their absence. By the transferable vote we use the 85 or 83 per cent. of non-effective votes in the examples we examined, and thus secure true representation.

9. What are the actual published results obtained by the use of the transferable vote in two elections at Pretoria, two at Johannesburg, and in five Parliamentary elections in Tasmania? The result is that as a rule 99 per cent. of the votes it is possible to use are actually used in electing the members. In one case in Tasmania it was 97½ per cent., but that is just six and a half

times the 15 per cent., we found effective in Cape Town. In the Senate elections in the Union of South Africa still more satisfactory results were got, 100 per cent., and in a small model election held at Rondebosch, where 50 voters elected three members from six candidates, 49.53 votes were given to the three members out of 50 votes; 10.53 votes more than the quotas needed for the election of the three members.

10. These excellent results were obtained by the co-operation of the voters and the returning officer.

The voter, instead of putting a cross opposite the one candidate's name for whom under the present system he votes, marks in order of his preference 1, 2, 3, 4, or as many more names as he chooses. This is all the voter does.

The returning officer examines, and counts all the voting papers. If electing seven members, he divides the number of valid votes by 8, and adds one to the quotient; this gives him the "quota," or minimum number of votes that ensures election. He then distributes all the valid votes in heaps for each of the candidates marked 1 upon them, counts these heaps, and puts them in the candidates' boxes. He enters at the top of a temporary transfer sheet, in order of their preference, the names of all the candidates, and below them the numbers of original, or first-preference votes, they received. This is the first count.

He then looks for all the votes marked 2 on the voting papers given to the eighth candidate, and distributes them to all the candidates, just as he did on the first count; and he enters their number below the others on the temporary transfer sheet, and prefixes the name of the candidate whose votes they are. He does the same with votes for the ninth candidate, and so on to the lowest. He then distributes in like manner any surplus second-preference votes. He now makes sure, that all votes except those of the seven highest candidates on first and second-preference votes are distributed; and only those. He then adds the combined first and second-preference votes for all the candidates: this is the second count. A third and fourth count follow on the same lines if necessary.

11. To ensure absolute accuracy the returning officer must observe two fundamental rules:—First, to exclude or eliminate no candidate's name on the temporary result sheet till every effective vote is allotted; and second, to use no lower preferences till all the higher ones have been allotted. The regulations followed at present are unsatisfactory in small elections from these two rules not being observed. If they are followed, both surplus votes and unsuccessful candidates' votes are distributed with arithmetical precision, and we get an absolutely correct method of counting.

12. Compare these excellent results, obtained by the use of the transferable vote, with the present state of matters. We have glanced at Gwelo, where, as at Umtali, each voter has one vote; at Bulawayo he has three votes. Not only are there three mem-

bers for Bulawayo with its 2,440 voters, but each of these voters has three votes, one for each member; and yet Mr. Gordon Forbes advocates for Bulawayo three single-member constituencies each with a single vote. This would deprive the Western Division voters of two-thirds of their present votes. I am not surprised; for this block vote, at present in operation, works badly; the minority are not only once beaten at every election, but three times over, once in the case of each of the three members. How can one expect them to go on voting; how can one prevent their becoming apathetic and staying away from the poll, knowing, as they do, that they will always be beaten three times at every election? If the minority stay away from the poll, what stimulus is there left for the majority of voters to prevent their staying away also, feeling sure, as they well may, that their members will be returned without the effort or trouble of voting on their part? Hence comes apathy, not only at election times, but always; and loss of interest in the doings and sayings of the members, whom they do not help to elect.

With the transferable vote, Mr. Gordon Forbes would get the equivalent of his three one-member constituencies; and not only that, but would give each voter the certainty that his vote would become effective. Each quota of the Western Division electors could elect their member, who would get nearly 778 effective votes in place of now, as at Gwelo, 117 effective votes.

Salisbury would be affected in the same way so far as regards its block vote for two members; and Colonel Grey in his temperate, well-balanced appeal for the Northern Division showed that it could give the quota, so far as numbers go, to three members. He gives the registered voters for his division at 2,360, those for the Western Division as 2,240, and estimates the other two at about 700 each. This gives a voters' register of 6,200, and for seven members a quota of 776, while he reckons the voters at Hartley, Lomagundi and Mazoe as about 787. The 686 votes cast at Gwelo show that the Midland Division probably is underestimated at 700; but in any case they presage a fine contest for the next election.

13. There will be a contest which will bring into strong light the justice of the claim of the rural voters all over the land to have the opportunity of voting at every Civil Commissioner's office, and every post office, or railway station, or school and church, and thus to get some sort of approximation to the facilities the urban voters enjoy.

The transferable vote, we have seen, makes in practice every vote effective; let us shortly consider how this affects the Voter, the Candidate, the Member, and the Country:—

14. First as to the voter:—The knowledge that his vote will be effective will help that man of his choice, who needs his vote, to secure his quota and his election, will make him vote, if you give him the facility to do so; it will further make him

anxious to get all other voters to vote also, and to get every one of his friends on the register of voters.

Even where zeal for his own side fails to induce him, the knowledge that every vote given on the other side will become effective will drive him to the poll, will compel him to vote.

15. The mining interest now is, and probably for many years to come will be, predominant over the farming and the urban or mercantile interest. The miners and their labourers are the customers of the farmers; but the day will surely, and soon, come when mealies will be produced and exported in larger quantities, and with them cereals, dairy produce and meat in various forms, and also tobacco.

In raising these, the farmers will year by year increase the value of the land, which, in spite of their importance and necessity, the miners are decreasing. The farmers will always be scattered over the rural areas as the miners are now, but ever widely and more widely. The transferable vote adapts itself to all these varying states of the population, and gives each section of the community its due proportional representation. To give the scattered rural voters all possible facilities, we must remember that ballot boxes need not be large where voters are few and scattered, that they are easily carried, that there is no need to declare the result of the poll on the day of election.

At polling centres it is necessary that the voter should be known to the presiding officer, or his identity vouched for by a known person. Where could this be done better than at every Civil Commissioner's office, every post office, or every railway station, or school or church? And thus a vigorous attempt would be made to diminish the inevitable drawbacks of the rural voter when you for the first time give him the certainty that his vote will tell.

The ballot paper keeps its own secret. A qualified presiding officer, to whom most of the voters would be personally known, or could be identified by a known witness, is to be found at all the suggested centres; their work and their pay would be small but the case of the rural voter is a very important one, and calls for attention.

16. When a man has taken some trouble to vote, and has carefully considered his order of preference; when he has marked two or three, or it may be all seven, of the subsequently elected members on his voting paper, he will take an interest in their sayings and votes, and in that of the others. This will develop an intelligent interest in the politics of his country; he will look forward with pleasant anticipations to his next chance of voting, and think carefully of the order of his preference.

Thus the transferable vote tends to secure more voters on the register and at the polls, and a more intelligent interest in the politics of the country.

17. Secondly, How does it affect the candidates? It is impossible to canvass Southern Rhodesia, and freed from the

expense, the worry, the irksome work of canvassing, there will be more candidates, the field of choice will be widened. A vote is a valuable right of the voter, to be used with intelligence for his country's good; not to be given for the asking, even if the voter is a poor working man, and if the candidate's wife drives up in her motor to ask him for his vote for her husband. To canvass a man for his vote is rather to insult his intelligence, and it is degrading and greedy begging on the part of those who do it. It tends, too, to give the least intelligent voter, the man who will give his vote because he is asked for it, or is driven to the poll, the casting vote in the election of the member.

The young, intelligent hard-working farmer is unable to bear the present expenses of a contested election, but could afford at a suitable time to attend the short meetings of the Legislative Council, and come forward and be an acceptable candidate to his fellow farmers, the future backbone of the country. Merit to a greater extent than now would become the qualification for the Rhodesian member of the Legislative Council, and that merit must be shown by public work, by public speaking on the platform, by letters and articles in the press, by taking an active part in all local Associations, thus showing his fitness for election as a member. When not 17 per cent. of the votes, not 117 effective votes, but a quota of 776, is required for election, the member's name must be known in Rhodesia, so that he can get general support, as well as all the local votes in his vicinity. There ought to be the best men all over the country coming forward as candidates, from whom the voter can pick out the seven men most fit to serve their country, make its laws, and determine its policy. No longer will one of the first questions asked regarding a candidate be, Is he able and willing to pay his election expenses? The change will be greatly to the advantage of Rhodesia.

18. Thirdly, How will the transferable vote affect the member? He will know and feel that he has not crept into the Council with the aid of, it may be, a very small relative majority of effective votes, got with much labour, trouble and expense, but that he has a quota of voters at his back, whose eyes are fixed on him and his sayings, his doings, and his votes. His effort will be to earn their appreciation of his work for the good of their common country, and so make sure the question of his return when the next election day comes round.

Collectively the elected members, elected by the effective votes of all the people, will feel, know, and realize that they speak for them with just as much authority as the five nominated members across the table for the Company. They will be urged and spurred on to do their best, knowing that they are not members only, but truly the representatives of the whole people, who have elected them. This will facilitate the common aim and interest of the inhabitants of Rhodesia and of the Chartered Company,—the good and the progress of the country.

19. Fourthly, How will it affect the country?

Voting as one large constituency will allow every voter, the miner for instance, to vote just where he happens to be working.

When one large and important question stirs the mind of the country at an election, it gives an opportunity for the expression of that opinion on a finely graduated scale exactly in proportion to the strength of the opinion, that is, to the number of the voters who hold it. There are eight steps or degrees on the scale from 7 to 0, through 6 to 1, 5 to 2, right down to 0 to 7.

Seven is really the least number that allows the good points of proportional representation to be seen.

With three members, the lowest number that can be elected by this system there are fewest advantages. Only three grades are on the scale, 3 to 0, 2 to 1, 0 to 3; each differing from the other by one-third of the members. Odd numbers give better results than even ones: thus with six members we have the same scale, one-third of the members, only as with three, 6 to 0, 4 to 2, 0 to 6, two-thirds in 5 to 1. With five we have five grades.

When Rhodesia attains twelve elected members, and that may be in a few years, with the present rate of increase, the question of two constituencies with five and seven members respectively may arise. At present the transferable vote would secure all over Rhodesia one voter one vote, one vote one value, and equal number of votes for each member and all votes effective.

20. The transferable vote would stop all need for redistribution. All demand or agitation for it would cease. There would be no need for expensive commissions either recurrent or constant as in the Union of South Africa, no troublesome unsatisfactory attempts to settle boundaries, with much unsettlement of many men's minds.

21. The question of additional representation would at once be automatically solved. When the register showed an addition of one-seventh of the present number of votes, an additional member might be elected.

22. The question of bye-elections admits of an easy and very satisfactory settlement. We cannot elect one member with the transferable vote, but when a member dies or resigns, we can examine the voting papers which secured his return, and can get the name of the next available candidate, the very man that those identical voters, who have lost their member, would have chosen at the election had their late member's services not been available then. Thus without expense, without loss of time, you supply what they have lost, the member and representative they themselves would have chosen to represent them.

23. To recapitulate shortly the substance of my paper. I have pointed out what the transferable vote is, and how it makes every vote effective. We have found that majority election by a relative majority inevitably leads to a majority of non-effective votes, and such misrepresentation, that in twenty-five

years there was only one election to the British Parliament, when the results approximately represented the relative numbers of voters.

We have seen that sectional election with the transferable vote secures true representation in cases where three or more members are to be elected; that it works well wherever it has been tried, as in Tasmania, the Transvaal, and the South African Union, making 99 per cent. of all the votes it is possible to use effective in the election of members. We have described the voter's part, the returning officer's work, and the two fundamental rules that ensure absolute accuracy in counting. We have compared its results with those from the present plan of voting in Rhodesia, and drawn special attention to the needs of the rural voter.

We have seen how effective voting would affect the voter, the candidate, the member, and the country; considered the advantages of voting as one constituency for seven members, and seen how it would obviate the need for redistribution, provide automatically for additional representation, and solve in a satisfactory way the question of bye-elections.

It would make the elected members the true representatives of the voters, place them on a footing of perfect equality with the nominated members, and enable both successfully to secure their common object and interest, the improvement, the welfare, and the progress of Rhodesia.

TRANSACTIONS OF SOCIETIES.

Royal Society of South Africa.—Wednesday, October 18th: Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S., Vice-President, in the chair.—"The spectrum of ruby": Dr. J. **Moir.** Two additional faint spectrum lines were described. Chromium had been detected as the colouring matter of artificial ruby. On heating above 300° C all the characteristic spectrum lines disappear. The spectrum is therefore due to chromium in a special atomic condition apparently not occurring elsewhere in nature.—"Some causes and effects of variation in the range of temperature": Dr. and Mrs. J. R. **Sutton.** A discussion of some of the more salient meteorological aspects of variation in the range of temperature. Harmonic constants of barometric pressure and temperature had been computed for months of great and for months of small range of temperature.—"Algebraical development of the elliptic perturbative function used in the theories of planetary motion": R. T. A. **Innes.** Tables were given for the calculation of certain functions. "A supposed new mineral from Du Toit's Pan, Kimberley": Prof. B. de St. J. **Van der Riet.** The author considered the supposed mineral to have been derived from Calcium carbide that had been used in acetylene generators on the mine. In the generators at Stellenbosch the author had found pellets similar to those brought from Kimberley. In both cases they were accompanied by slaked lime, the variations in hardness were similar; in composition they ranged from iron carbide to iron silico-carbide; both evolved an odour of acetylene when crushed, and neither contained notable quantities of titanium.—"Further magnetic observations in South Africa during the years 1910 and 1911"; Prof. J. C. **Beattie.** Reduced results of observations for determining the secular variation of the magnetic elements, and results of additional observations in the Western Transvaal and the

Eastern Districts of the Cape Province, with a discussion on the magnetic states of these regions.—"Action of radium salts on glass": Prof. W. A. D. **Rudge.** As the result of experiments carried on for three years with radium salts sealed up in glass tubes, sections of which were afterwards cut and microscopically examined, in order to ascertain the depth to which colouration had penetrated, a zonal structure was observed, with abrupt changes in depth of colouration at the junction of successive zones. It was concluded that the colouration was due to β and γ rays, as well as to a particles and emanation.—"A new species of *mesembryanthemum* from the Transvaal; and notes on the genus *Ficus*": J. **Burtt-Davy.**

South African Institute of Engineers.—Saturday, October 14th: Mr. F. H. Davis, President, in the chair.—"The manufacture of turbines as a future industry": A. S. **Ostreicher.** The author expressed the conviction that water turbines of a moderate size, up to six feet in diameter, would be the first engineering specialities to be successfully manufactured in South Africa. He proceeded to describe the manufacture of a modern Francis turbine, illustrating his remarks by means of diagrams, and referring specially to the attainment of high efficiency and the methods of speed regulation.

Geological Society of South Africa.—Monday, October 16th, Dr. E. T. Mellor, President, in the chair.—"Xenoliths in gabbro, near Belfast, Transvaal": J. P. **Johnson.** Attention was drawn to patches of abnormal composition occurring in an otherwise normally homogeneous gabbro of considerable extent, on the farm Wintershoek, and having the appearance of altered inclusions. The most remarkable of these xenoliths consist of a coarse-grained rock, bearing a resemblance to the eclogites of the diamond pipes: it is an evenly granular aggregate of garnet, quartz, and some semi-opaque greenish mineral with a well-developed cleavage.

ADDRESSES WANTED.

The Assistant General Secretary (P.O. Box 1497, Cape Town) would be glad to receive the correct addresses of the following members, whose last-known addresses are given below:—

Aspland, C. Hatton, Witwatersrand Deep, Ltd., P.O. Box 5, Knight's, Transvaal.
Barton, Ernest Mortlock, Director of Works Department, Simonstown, Cape.
Bay, Dr. B., P.O. Box 5513, Johannesburg.
Bell, W. Reid, M.I.C.E., F.R. Met. Soc., M.I.E.S., P.O, Box 2263, Johannesburg.
Boulton, H. C., c/o Messrs. Pauling & Co., Ltd., Broken Hill, Rhodesia.
Brown, W. B., c/o Engineer-in-Chief, S.A. Railways, Cape Town.
Champion, Ivor Edward, P.O. Roberts Heights, Pretoria.
Crockett, John, 10, Transvaal Bank Buildings, Johannesburg.
Dickie, Andrew, 475, Currie Road, Durban, Natal.
Leech, Dr. J. R., 4th Avenue, Melville, Johannesburg.
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Mirrilees, W. J., 9, London Chambers, Durban.
Nichol, Thomas Thompson, P.O. Box 34, Springs, Transvaal.
Nicholas, W. H., Durban High School, Durban. Natal.
Nicholson, J. Greg, Leliefontein, Government School, P.O. Carolina, Transvaal.
Petersen, H. T., P.O. Box 5, Cleveland, Transvaal.
Preston, James, 89, Arnold Road, Observatory, near Cape Town.
Southwell, Miss Jessie, 270, Visagie Street, Pretoria.
Van Oordt, J. F., Harrismith, O.F.S.

SELECTIVE ABSORPTION OF SUBSTANCES IN THE EARTH'S CRUST.

By Professor E. H. L. Schwarz, A.R.C.S., F.G.S.

On the theory of the earth having passed through a molten stage, the crust is regarded as a siliceous slag rejected by the cooling globe which is essentially composed of metals. In this way the specific gravity of the crust, which is about 2.7, is accounted for; the earth, as a whole, is about 5.5, and hence the interior portion would be about 7, or approximately the specific gravity of iron. Chamberlin's planetesimal hypothesis, and the developments introduced into the original conception by later authors, account for the earth's centre being of the density observed, by supposing that it consists of meteoric matter, essentially iron and various basic silicates: the crust, in this assumption, would be the result of processes which have taken place on the surface, which have removed the iron and magnesium, and enriched the crust in silica, lime and soda. It is the purpose of this paper to draw attention to the movements of the elements iron, magnesium, calcium, and sodium, at present in action on the earth, which, if not proving the planetesimal hypothesis in all its points, at any rate prove that if the earth had been built up along the lines of that hypothesis, the earth's crust could not have been otherwise than it actually is.

In South Africa we have a most clear illustration of the movement of the elements named above, in the weathering of dolerite in the Karroo, where no soil hinders the free action of the movement. The rock consists of the following substances: the amounts given are those of a dolerite of the Siebengebirge on the Rhine, and are typical.

Silica	52.63	practically insoluble.
Alumina	13.53	
Iron Oxide	12.6	
Lime	8.44	
Magnesia	6.17	
Potash	1.61	
Soda	4.28	
Water	1.55	
	100.81	

Such a rock forms kopjes in many parts of South Africa; in many of the drier parts, the water draining from the hillsides is not sufficient to flow away in rivers, but collects at the foot of the hills, in shallow lakes or pans. As there is no outlet for the waters, all substances weathered out of the dolerite, and carried in solution by the water, must come to rest in the pan, and, on evaporation of the water, ought to form a deposit on the floor of the pan. The lime and soda do certainly accumulate in the pan in the form of gypsum and common salt, the former almost invariably crystallising, either in the mud below the surface, or just on the surface, while the salt remains obstinately on the top of all. We should expect, from the analysis of the dolerite, that there would be a much greater deposit of iron and, to a lesser extent, of magnesia, but of the former there is no trace whatever, while the latter may be intercepted in wells and borings round the edge of the pan, where it makes the water bitter from the epsom salts dissolved in it. We have here, then, a clear instance of the selective absorption of the earth's crust, which acts like a sieve to iron, causing it to sink immediately downwards, letting the magnesium through, though more slowly than iron, but forming an absolutely impervious medium to the lime and soda salts.

If the whole country were composed of dolerite, and this action were to continue for a very long time, till a very thick layer were completely weathered, we should find that that portion of the earth's surface would eventually consist of silica, alumina, lime and soda salts. In due time some of the silica would be converted into quartz, which would form the grains of sandstones; some of it would remain combined with alumina, as kaolin, in the form of clay; the lime would unite with carbon dioxide of the air (the sulphur of the gypsum supplied by the pyrites in the shales of the normal South African kopjes would be absent), and the soda would be represented by salt. That is to say, the essential constituents of the normal three types of sedimentary rocks, sandstones, shales and limestones, would be present, and the salt of the ocean would also be there; the iron and magnesium, so rich in the original rock, would be represented by small traces. If the whole earth were originally made of rocks of the dolerite composition, then the sediments would form in the manner they do now, and with the same composition. On Chamberlin's hypothesis, the earth is supposed to have originally consisted of ultra-basic rocks and iron. The composition of the ultra-basic rocks is practically the same as that of the dolerite, with less silica, hence the selective absorption of the earth's crust, directly water became formed, would result in the crust as we find it, with silica, alumina, lime and soda predominating over all other oxides of elements—disregarding hydrogen oxide, or water and oxygen of the air, which form the media by which the absorption is rendered possible.

The silica in the earlier periods would be colloidal silica; indeed, quartz could not have existed in the earlier stages of the earth's history on the planetesimal hypothesis, as the continual bombardment of meteorites on the growing sphere would have kept the surface at a white heat, and quartz cannot exist above a temperature of 800 degrees C. The colloidal silica weathered from the basic silicates would be carried to the ocean, and would there form layers of chert. After immense periods of deposition, sufficient sediment would accumulate to allow the recrystallisation of the chert under pressure, as quartz. The great time necessary for a thick deposit to form in this way, in contrast to the comparatively short time requisite in later periods, is due to the fact that in those ages the silica was spread out over the ocean floor without reference to the boundaries, whereas the heavier mechanical deposits of later times were unable to be carried far from the land, and were hence deposited within at least two hundred miles of the shore. When sufficient material had accumulated, and earth movements had elevated the recrystallised siliceous sediments above the sea-level, then, for the first time, quartz became subjected to weathering, and the first true sand grains began their travel.

Alumina, united with silica and water as kaolin and clay, was formed from the commencement of the action of water and atmospheric oxygen on the rocks of the earth's crust exposed above sea-level.

The iron at once became absorbed, and travelled downwards as it does to-day. Where it goes to, and why, is a mystery I have tried to explain in the following way. First, as to why it goes downwards. Weak solutions of salts become ionised; that is to say, become split up into two parts; a metallic part which carries a positive charge of electricity, and an acid part which carries a negative charge. The positive, or metallic ion, is in the elemental condition, and hence, if a compound of iron is dissolved, a portion of it exists in the solution as metallic iron, and, as such, should be affected by the magnetic attraction of the earth's core.

Where it goes is a matter which we can, to a certain extent, explain by noticing that under special conditions deep-seated beds of limestone may become wholly converted into haematite, or iron oxide, by the percolation through them of solutions of iron derived from above. Generally speaking, also, the older the beds the more highly ferruginous they are; that is to say, when they were buried, the continual passage of iron-solutions through the interstices betwen the grains caused a certain amount of deposition of iron within them. Under certain circumstances the descending water may be returned through fissures to the surface as chalybeate springs, but the vast preponderance of iron dissolved from the rocks, as they weather on the surface of the earth, passes directly downwards and becomes lost, as far as our actual knowledge goes. It must accumulate at the base of the crust, beyond which no water derived from the surface can descend. Practically, no iron in solution reaches the sea in river water, however much iron-bearing rocks there may be exposed on the continent drained by the rivers. Where drainage is deficient, as on the flat coastal plateaux in South Africa, the iron in solution is precipitated under the soil, probably by organic agency, certainly the iron-bacterium *Crenothrix* is present in soil, but whether this is entirely responsible for the deposition, or whether some chemical deposition is superadded, is not yet determined.

It is significant, however, that where there is no soil, and, hence, no medium for the *Crenothrix* to live in, there no iron becomes arrested on the surface. The superficial deposits of this surface iron are very large in South Africa, forming ironstone gravel, *ou-klip*, or, as it is known in England, moor-bed stone (*ort-stein* in Germany). In cold latitudes the iron in the waters draining into lakes is likewise arrested again by organic agency, by various iron Bacteria, by the diatom *Gallionella*, and even by the leaves of higher plants, such as *Elodea*; but here, again, it is not certain whether the organisms are solely responsible for the deposition, but the constant presence of phosphorus in iron thus precipitated makes it probable that that is the case.*

Magnesium follows iron, but here we have a metal which is not magnetic; nevertheless, all substances are probably magnetic to a certain extent, and hence, from the analogy of iron, it is conceivable that the reason why magnesium descends in the earth's crust is the same that causes iron to do so, namely, that, as the earth's core consists largely of magnesium, the attraction of this on the ionised magnesium, in the weak solutions derived from weathering rocks, is sufficient to draw it towards the earth's centre.

That magnesium does descend we have already seen in the case of the weathering dolerite, but, on a larger scale, we see it in its descent in the dolomitisation of limestones. The older the limestone the more it is dolomitised, generally speaking. That this is a subsequent effect, and is not due to original composition, is proved from the fact that the dolomitisation progresses from the joints inwards towards the centres of the blocks. If a limestone, no matter how old it is, lies in a region where earth movements have not taken place, then the exchange of part of the lime for magnesia does not take place; but if the same limestone becomes caught in the press of earth movements, then the whole of the limestone is converted into dolomite. There seems to be necessary a certain amount of pressure to render the molecules of the compound sufficiently mobile to allow the exchange to take place. At the same time, this fact proves that a continuous shower of water holding magnesia in solution has gone on in both cases. The feebleness of the attraction of the magnesia centre-wards, however, allows a small percentage of magnesium salts to escape to the ocean, where it accumulates, but in very much smaller proportion than common salt or lime.

The lime displaced by the magnesia in a limestone which becomes dolomitised comes to the surface. The same applies to salt, which, if liberated from deposits which have become buried, seeks the surface. These facts are so extraordinary, and I have sought so vainly for any explanation of them, that I may be excused for throwing out a suggestion that may perhaps lead

* See Molisch, H.; Sitzungsberichte d. K. Akad d. Wiss., Vienna, October, 1910.

eventually to a solution of the puzzle. The various elements are deposited from solution by the electric current with varying ease. Thus, a given electro-motive force will deposit more iron and magnesium than sodium or calcium; as a matter of fact, calcium ought to displace magnesium, and does so, under normal conditions at the surface of the earth. The constant sinking of ions of iron and magnesium carrying a positive charge towards the centre of the earth may, in some way, cause the potential in the lower regions of the crust to be such that the stronger elements in the electro-motive series, such as sodium and lime, are repelled to the surface, the weaker ones being also repelled, but the centrifugal force, in their case, being counterbalanced by the centripetal one due to the magnetic attraction of the earth's core.

If this be so, then, as all metallic ions carry positive charges, directly metallic salts become dissolved by percolating water from the rocks in which they are held, they would tend to seek the surface, the stronger elements in the electro-motive series being those most strongly repelled by the accumulated positive charge at the base of the crust. The following is a short list of the metals arranged in the electro-motive series, beginning with the strongest, and it seems more than a coincidence that those metals which are most widely distributed on the surface lie towards the top of the series, whereas gold and platinum, which are scarce, lie at the bottom of the series, as if their feeble electro-motive force were insufficient to carry them in any quantity to the surface.

Electro-motive Series of Elements.

Potassium (*strongest*).
Sodium.
Lithium.
Calcium.
Magnesium.
Aluminium.
Manganese.
Chromium.
Iron.
Cobalt.
Nickel.
Hydrogen.
Platinum.
Gold (*weakest*).

Uranium Ores.—Recent discoveries of uranium ores are reported from the vicinity of Mount Painter, in the Flinders Range, South Australia. This is of potential importance in view of the close association of uranium with radium, and the comparative rarity of its ores in other parts of the world. Ores containing niobium and monazite are also stated to occur in the locality referred to.

NOTES ON INVESTIGATIONS ON SOME SOUTH AFRICAN TOBACCOS.

By Marshall Lundie.

Tobacco has been cultivated in South Africa since the beginning of the eighteenth century. It has never been produced in such quantities that it could be exported, but it was just sufficient for the demands in the Cape Colony, where it always obtained good prices. The cultivation of tobacco recently became so important in the Colony that in 1886 the Government appointed an expert, Mr. R. Schenck, to investigate and report on the condition of this branch of agriculture in the Colony. His reports on the subject appeared as Blue Books, and contained also the results of a large number of analyses made by Dr. C. F. Juritz, of soil and tobaccos taken from the principal tobacco-growing districts, *viz.*, Piquetberg, Strandveld (Caledon district), Heidelberg, Riversdale, George and Oudtshoorn. From these reports it appears that the cultivation of tobacco was carried on in a very primitive manner, the principal idea of the tobacco grower being that the land intended for the tobacco must receive a superabundance of powerful manure, chiefly sheep manure. It is, therefore, not surprising to find that the amount of Nicotin in the tobacco grown under these conditions was excessive, and that also the percentage of ash was very high.

The tobacco-plant requires a large quantity of lime and potash in order that the leaves burn well. The chlorides increase the quantity of the production, but reduce the quality and interfere with the combustibility. The analyses of different kinds of South African tobacco prove that there are insufficient quantities of lime and potash and too large quantities of chlorine compounds.

In many cases the tobacco does not burn properly, yielding a black ash resembling charred leaves rather than pure white ashes. This is due, of course, to the excess of chlorides contained in the tobacco, which are derived again from the excessive manuring with sheep's dung.

In the Colony sheep's dung must be used for manuring, and the evil effects it has on the tobacco must be checked by some method. Green manuring is an excellent way of raising the quality of the tobacco. This consists in planting on the tobacco fields certain crops, chiefly legumes, which are ploughed in shortly before transplanting the young tobacco plants. The advantage of this green manuring consists in removing from the soil such compounds as are injurious to the quality of the tobacco. The substance of this crop itself undergoes decomposition in the soil, and forms a most suitable food for the plant. The physical condition of the soil is much improved, and moisture is retained in the soil for a longer time.

To illustrate the high percentage of common salt that the tobacco plant can absorb into its system, the following extracts, from analyses of different kinds of tobacco made by Dr. Juritz in connection with Mr. Schenck's reports, are taken:—

Locality, etc.	Ash contains Common Salt per cent.
Strandveld, unirrigated soil	30.14
Piquetberg, manured with sheep's manure	30.24
Piquetberg, manured with sheep's manure and lime	30.74
Oudtshoorn, manured with goat manure	30.86
Strandveld, unirrigated soil	30.95
George, never manured	31.82
Heidelberg, manured with sheep's manure and partially irrigated	34.37
Riversdale, manured with cattle manure and irrigated	35.13
Hex River, manured with cow-dung	38.39

As examples of the high percentage of ash the following are given:—

Locality, etc.	Ash: per cent. of Air-dry Leaf.
Oudtshoorn, manured with sheep's manure and irrigated once a fortnight	19.25
Warm Bokkeveld, manured with sheep's manure	19.46
Strandveld	19.76
Oudtshoorn, manured with goat's manure	20.41
George, never manured	20.59
Oudtshoorn, manured with goat's manure, alluvial soil	20.63
Hex River, manured with cow-dung	20.76
Oudtshoorn, manured with goat's manure	20.80

And of nicotin:—

Locality, etc.	Nicotin: per cent.
Heidelberg, manured with sheep's manure and partially irrigated	4.24
Piquetberg, unmanured	4.39
Swellendam, manured with cow-dung and irrigated	4.56
Piquetberg, manured with sheep's manure	5.20
Oudtshoorn, manured with sheep's manure and irrigated once a fortnight	5.79
Oudtshoorn, Karoo soil, manured with sheep's manure	6.95

All classes or types of tobacco belong to a single species *Nicotiana tabacum,* closely related to wild and cultivated plants, among which are the petunia, Irish potato and egg plant.

The locality, climate and the soil in which the crop is to grow will decide the class of tobacco to be cultivated. The type or variety, however, is dependent on these conditions, and also more or less on individual notions or desires of the planter, knowledge of the kind grown, peculiarities for working the soil, etc.

All crops are true to seed; grades are the result of soil differences, peculiarities of climate, of planting and cultivation methods, and of systematic and intelligent fertilising. As the market calls for these distinct grades in tobacco this point becomes a very important one for the planter to observe.

1. *Nature of Soil.*—As to the nature of the soil, it is an established fact that soil rich in humus and poor in chlorides yields a much better quality of tobacco than a soil which contains no humus and is full of chlorides, such as the brack soils of South Africa are.

The inorganic constituents which are absolutely necessary to all plants, and consequently also the tobacco, are: Potash, lime, magnesia, oxide of iron, phosphoric oxide, sulphuric oxide, ammonia, and nitric oxide. Magnesia and oxide of iron are invariably present in all soils in sufficient quantity.

The fitness of the soil for tobacco culture depends, however, not only upon the presence of a sufficiency of the indispensable constituents in a proper condition of chemical combination, but also on the absence of any excess of such injurious compounds as the chlorides, which readily enter into the system of the plant, deteriorating the quality of the leaf. Growing crops are, perhaps, as much dependent on the physical condition as upon the chemical composition of the soils in which they grow, and the texture of the soil may be accepted as possessing great influence on the quality of the tobacco produced thereon.

The time of harvesting and the manner of curing have much to do with fixing types or grades of tobacco, and even more important is the intelligent cultivation of the plant and its proper fertilising.

The peculiar adaptation and value of tobacco leaf for cigar purposes being due to the texture and aroma of the leaf, certain fertilisers must be rigorously discarded from the soils from which superior tobacco is expected. Rank, coarse, organic manures and all mineral fertilisers (such as chloride of potassium and kainit) containing chlorine must be especially avoided. Mineral fertilisers, however, of proper composition have proved capable of producing the very highest type of cigar tobacco leaf.

Nitrogen and potash are the main plant food requirements of this crop, phosphoric acid being of relatively little importance in its growth. The burning quality of the leaf, on which so much of its value depends, is largely controlled by the relation between the properties of the nitrogen and potash supplied to the crop. Tobacco requires heavy applications of fertilisers; one ton to the acre not being an exceptional quantity. The application should contain:

Phosphoric Acid	4 per cent.
Nitrogen	5 ,, ,,
Potash	9 ,, ,,

The potash should be applied in the form of high-grade sulphate, sulphate of potash-magnesia, or silicate of potash, and the nitrogen preferably from nitrate of soda, cotton-seed meal or the finest grade of old and partially decomposed Sea Island guanos. The phosphoric acid is most economically obtained in the shape of acid phosphate, although cotton-seed meal and guano contain small quantities of this essential.

2. *Climatic Conditions.*—With reference to the climate, the tobacco grown in a damp climate does not lose so much water by evaporation from the large surface of the leaves as in a dry climate with continuous sunshine. In a dry climate the plant draws in by the roots much more water than in a damp climate, and with the water taken up by the roots a larger amount of saline matter enters into the system of the tobacco and increases the percentage of ash. In many cases the cause of an exorbitant amount of chlorine compounds in the tobacco is to be traced to peculiar methods of irrigation. The soil not being loose enough, the fine fibrous roots of the tobacco plant cannot penetrate sufficiently deeply into the soil. The water in many instances is led directly on to the plant, and this retards the development of the roots, because the principal roots, which provide the tobacco plant with food, are near the surface, and the plants can thus satisfy their requirements of moisture without developing long roots. In this surface soil are the largest amounts of chlorine compounds, which show themselves in dry weather as a white efflorescence on the surface. The solubility of these salts in water is much greater than that of lime or potash compounds, and since the water is led directly on to the plant, it dissolves the surface salts first and supplies the chlorine compounds to the plant. This can be prevented to a considerable degree by loosening the soil to a greater depth and leading the water in between the rows of tobacco plants, thus compelling the plants to extend their roots and live on a larger portion of soil. Tobacco grown under these conditions does not burn so readily as tobacco grown in a humid atmosphere.

It is also known that the same variety of tobacco contains less nicotin when grown in a damp climate than in a sunny climate. Some of the districts where tobacco is grown are distinguished by a fine sunny climate, but the tobacco contains such an excessive quantity of nicotin that it is more suitable for the manufacture of sheep-dip than for the manufacture of cigar or pipe tobacco.

The writer has continued the researches made by Mr. Schenck and Dr. Juritz in 1886, and has examined a number of different tobaccos obtained from new countries like the Transkei and Rhodesia. It is of interest to compare the amount of nicotin and ash in these tobaccos with the results given above.

The following results are the average of at least three determinations. It may be stated that the determinations made in each case did not materially differ from one another:—

Locality, etc.	Nicotin per cent.	Ash per cent.
Virginian Leaf (Hester), flue-cured Rhodesian grown	2.14	12.15
Turkish Tobacco (Rhodesian grown)	2.52	10.25
Pondo Tobacco, Elliotdale District, Pondoland	1.45	14.58
Kafir Tobacco, Willowvale District, Transkei	1.13	14.26
Karoo Tobacco, Oudtshoorn	4.92	19.16
Cango Tobacco, Oudtshoorn	1.44	12.02

It is of interest to compare these latter results with the composition of some of the more famous varieties of tobacco, most of which contain 17.2 per cent. of ash, whereas the percentage of nicotin varies.

Best Havana Tobacco	contains	2.5	per cent.	of	nicotin.
Brazil	,,	,,	2.0	,,	,,
Sumatra	,,	,,	4.12	,,	,,
Kentucky	,,	,,	4.53	,,	,,
Maryland	,,	,,	1.26	,,	,,
Domingo	,,	,,	.82	,,	,,
Ohio	,,	,,	.68	,,	,,

In all tropical and subtropical countries much has been done in recent times for the improvement of tobacco by proper selection of varieties suitable for climate and soil. In the Transvaal, too, much has been done already through the energy of the Director of Agriculture to improve the cultivation of tobacco.

It is to be hoped that in those parts of South Africa which have summer rains, Transkei, Natal, Transvaal and certain parts of Rhodesia, the cultivation of tobacco will receive more attention than it does at present. There is no doubt that by proper cultivation a very superior tobacco can be produced in these countries which will stand comparison with the best tobaccos grown in the tropical and subtropical countries which at present supply the European market.

The following is the method adopted by the writer in determining nicotin in tobacco.:—

The tobacco leaves are first dried at a temperature of between 60° and 70°, or in a desiccator, to remove all moisture. The ribs are then removed and the leaves crushed in a mortar to a fine powder. Twenty grammes of this fine tobacco powder are weighed out in a porcelain dish, 10 c.c. of the sodic hydrate solution added (6 grammes of solid sodic hydrate dissolved in 40 c.c. of water and filled up to 100 c.c. with alcohol of 96 per cent volume), and the contents of the dish mixed, transferred to a Soxhlet apparatus, and the nicotin extracted by means of ether. This is allowed to continue for about two hours, when all the nicotin contained in the 20 grammes taken will be in solution in the ether. The ether is recovered by attaching the flask of the Soxhlet apparatus containing the nicotin in ether to a long Liebig condenser and distilling over the ether. The residue in the flask will be the nicotin, chlorophyll, etc. (The ether may also be expelled by placing the flask in a water-bath previously heated to about 50° Centigrade and placed at a safe distance from any flame. Even the hot sun suffices to drive off the ether.) To the residue in the flask add 50 c.c. of sodic hydrate solution made by dissolving 6.4 grammes of solid sodic hydrate in 100 c.c. of water. Attach to this flask a cork with a glass inlet connected to a boiler, and the outlet to a Liebig condenser, and hence distill over the nicotin until the distillate measures 500 c.c. In this distillate will be all the nicotin contained in the 20 grammes of tobacco. Remove 100 c.c. of this by means of a pipette into a clean beaker, and titrate by means of a decinormal solution of sulphuric acid, using Cochineal* as indicator, until violet blue turns onion red. Every 1 c.c. of decinormal sulphuric acid indicates .0162 gramme of nicotin. Repeat, using 100 c.c. each time, and take the average number of c.c. of decinormal sulphuric acid used.

Let x = average number of c.c. used for each titration.
Then $x \times .0162 \times 25$ = percentage of nicotin.

Wireless Forecasting to Ships at Sea.—For the benefit of vessels on the Atlantic the Bureau Central Météorologique de France has begun a regular system of despatching wireless messages broadcast from the Eiffel Tower, Paris, daily at 11 a.m., Greenwich mean time. These messages will include the latest observations of barometric readings, the direction and force of the wind, and the state of the sea, and will comprise reports from Reykjavik, Iceland; Valentia, Ireland; Ouessant, France; La Coruna, Spain; Horta, Azores; and Saint Pierre-Miquelon, America.

* The cochineal indicator used is obtained by dissolving 1 gramme of powdered cochineal in 20 c.c. of alcohol and diluting to 100 c.c. with water.

TRUTH AMONG THE PRAGMATISTS.

By Rev. Sidney Read Welch, B.A., D.D., Ph.D.

Amongst the recent systems of philosophy that have attempted to give us a reasoned account of the universe which falls within our experience, pragmatism is the most loudly trumpeted. Its vogue in popular literature is due to the fact that it has a simple and taking meaning, which is not its real meaning, *i.e.*, not that which we get from its chief exponents, when they are pressed by the cross-examination of the profane.

It would be idle to try to examine the whole basis of its philosophy in half an hour. But perhaps we may deal briefly with one of its aspects, and that not the least important. "What is truth?" is a question that every philosophy must face. The pragmatists have given their answer, and it is this that we shall try to understand.

I propose to examine the pragmatic definition of truth according to pragmatic methods of arriving at the truth. What the methods are may best be stated in the words of an arch-pragmatist, Prof. W. James.

> "The pragmatic method is primarily a method of settling metaphysical disputes that otherwise might be interminable. What difference would it practically make to anyone if this notion rather than that notion were true? If no practical difference whatever can be traced, then the alternatives mean practically the same thing, and all dispute is idle. Whenever a dispute is serious, we ought to be able to show some practical difference that must follow from one side or the other being right." *

Reading the statement of method, one is at once prepared to admit with the pragmatists that pragmatism is not altogether a new system, but rather a new name for some old ways of thinking. There is a dangerous family likeness between the above method and that of the noble knight, Sir Hudibras:

> For when disputes are weary'd out,
> 'Tis interest still resolves the doubt.

To make the likeness more startling, the pragmatists actually use the word interest in this connexion. Thus Schiller, in his "Studies in Humanism"†:

> "To determine, therefore, whether an answer to any question is true or false, we have merely to note its effect upon the enquiry in which we are interested, and in relation to which it has arisen. And if these effects are favourable, the answer is true and good for our purpose, and useful as a means to the end we pursue."

To hold the balance even between the pragmatists and Butler's noble knight, it is only fair to state that Sir Hudibras held self-interest to be the ruling test, whilst the pragmatists generally have imagined that they can establish an interest entirely sub-

* "Pragmatism." p. 45.
† P. 154.

jective in practice which is not self-interest. How far they have succeeded in establishing this latter distinction cannot now be fully argued. But a strange phenomenon will give a clue to their small success. They have failed to bring home this distinction to most of the learned philosophers, who have appreciated their speculations with some degree of sympathy. Prof. James has written a volume to reply to the misunderstandings of his critics on the meaning of truth. Having propounded in pragmatism a philosophy which boasts of its singular privilege of systematising the concrete imagination of the average man, he is much surprised that there should be such difficulty in grasping his meaning.

"It seems as if the power of imagining the world concretely might have been common enough to let our readers apprehend it better, as if they might have read between our lines, and in spite of all our infelicities of expression, guessed a little more correctly what our thought was." *

Now if there is one field in which the average reader or listener is competent, it is the field of concrete imagination. And Prof. James is a master in the art of apt illustration and the concrete example. If in such a fertile field, and with his natural ability, he has failed to be lucid in his original exposition or in its subsequent defence, we can only accuse the recalcitrant nature of the subject-matter. His meaning remains vague and shadowy, because his definition of truth is loose, variable and liable to all the irregularities of the human will when not controlled by some objective reality outside its own acts or wishes. The greatest difficulty in dealing with the pragmatist notion of truth arises from the number of definitions that they have given. Even Prof. James has elaborated several distinct expositions of the word and its content, which he himself has not as yet harmonised with any great success. But the most explicit or rather the least vague is that in "Pragmatism" (p. 222).

"The true, to put it very briefly, is only the expedient in the way of our thinking, just as right is only the expedient in the way of behaving. Expedient in almost any fashion; and expedient in the long run, and on the whole of our course; for what meets expediently all the experience in sight won't necessarily meet all further experiences equally satisfactorily."

In the mind of the plain man there is a radical opposition between expediency and truth. Hence we may infer that it is not quite in the sense of the plain man that the expedient is here offered as an elucidation of the true. The creative philosopher dares to give words new meanings. It is open to question whether this new creative departure is wise; but it is now more urgent to realise its import. The expedient in thought is, according to one pragmatist, that which unites in harmony with all a man's experiences.

"I start with two things [says Professor James] the objective facts and the claims (*i.e.*, truth-claims or, as we might gloss his words, the

* "The Meaning of Truth," p. 216.

hypotheses), and indicate which claims, the facts being there, will work successfully as the latter's substitutes, and which will not. I call the former claims true." *

The kind and value of the work which experience must do may become somewhat clearer, if we take a further statement from "Pragmatism"†:

"True ideas are those that we can assimilate, validate, corroborate and verify. False ideas are those that we can not. That is the practical difference it makes to us to have true ideas; that, therefore, is the meaning of truth, for it is all that truth is known as. It (*i.e.*, an idea) becomes true, is made true by events. Its verity is in fact an event, a process."

It goes without saying that these statements, taken together, contain a great deal that will command the assent of most men with regard to the psychological process of thought. Experience goes for a good deal in the acquisition of true ideas. A man's approximation to the true, according to science, is a progressive movement, ever going on, and his knowledge is being constantly supplemented by new discoveries. There are subjective and particular testimonies to the truth in every mind, which are unique and all-compelling, and cannot be easily communicated. Experience often has a long run before it overtakes the truth, after grasping vainly for it again and again under the form of various errors.

But all these observations, admirable as they are in themselves, would seem to be somewhat beside the mark when I am examining the meaning of truth. They tell me a great deal about the instrument or instruments which I am compelled to use in finding truth. I am vouchsafed much apt information about the working of the instrument. But I am actually anxious to gauge the noblest of its products. If I apply to some encyclopædic mind for full information of the characteristics of a daily paper, I must not be put off with the most eloquent and picturesque disquisition on the linotype machine. To my mind there is a further and more fundamental objection to the pragmatist conception of truth, from the purely philosophical standpoint, *viz.*, that whilst it offers to put us in possession of truth, it really palms off upon us a few of truth's consequences. Prof. Leslie J. Walker, S.J., one of the ablest critics of pragmatism, has pointed out‡ that:

"the consequences or workings of truth are not truth itself, as is evident from the fact that we speak of truth's workings or truth's consequences; thereby implying that truth is one thing and its workings or consequences something else which is not identical with it, but belongs to it, or follows from it, and is therefore predicable of it."

The man or system which wishes to persuade us to confound two things which the common sense of mankind has always felt to be

* "The Meaning of Truth," p. xix.

† P. 201.

‡ "Theories of Knowledge," p. 564.

separate articles must show better reasons than any pragmatist has yet shown.

But let us apply the pragmatists' own test to the definition of truth. Is it a true definition? Does it work? Is it in accordance with man's experience? Is it an idea that we can assimilate, corroborate, validate and verify? Is the true always useful even in the pragmatic sense of the word? All these ideas, distinct enough in common philosophy, are so linked together in the pragmatist dictionaries that all these questions can be answered together. To weaken the claim of any of them is to impair the worth of this chain-like definition of truth. I shall marshal a few of the reasons that seem to be fatal to these claims.

First, the definition does not work. For the expedient and the true cannot be confounded. As far as the individual is concerned, this is luminously clear. The life of many a man has been wrecked by truths, which, however undeniable they may have been, were certainly not expedient in any recognised sense of the word, *e.g.*, the proved treachery of a trusted friend. Hence the pragmatist guards himself against this interpretation by limiting the expedient with the phrases "in the long run" and "on the whole." But whilst this limits the field of the expedient, it increases enormously the demand upon the powers of the truth-seeker. In so doing it appears to reduce to an infinitesimal degree his chances of arriving at the truth. It is hard enough to forecast what will be expedient to-morrow. But if I am to make such a forecast as to the expedient "in the long run" and "on the whole," I am essaying a task too great for any individual. I may, of course, vault over this difficulty by postulating the principle that there is a constant evolution of progress and betterment going on in the world, in which I am taking part. But such a colossal assumption, unproved and unprovable, would not tell me for certain that I may not be in some backwater of the stream of general evolution, where the laws of the current "in the long run" and "on the whole" are not verified. If the general drift towards some far-off divine event is to justify those who are in the current, when they confound their experience with the true, it will hardly justify those in the backwater. Here the contrary rule would hold. The preliminary problem of determining whether I flow with the tide of human progress or recede gently with the backwater is surely too great for a straw on the mighty waters, unless you will allow it some fixed point on the shore by which it can take its bearings. But then you throw the expedient to the winds, and become an absolutist. For what truth such a human straw may gather from its experience will not be found in seconding the experience, but in connecting and inverting it, to get the proper direction and the real "hang" of things.

Secondly, it is conceded by the acutest of the pragmatists that reality must somehow be behind the truth. Says Prof. James*:

> "There can be no truth, if there is nothing to be true about. Ideas are so much flat psychological surface unless some mirrored matter gives them cognitive lustre."

If you ask what the connection may be between the satisfactory or useful or expedient ideas (which, according to the pragmatists, constitute the truth) and reality, they will tell you that the former lead to the latter, but cannot be said to correspond with it or copy it in any way. But we still await the pragmatist teacher who will show us how these leadings take place, and why their issue should be reality. To the uninitiated it seems incredible that any man should expect truth to issue from mere ideas if there is no connexion between them and reality. If pragmatist truth have no better foundation, it is not worthy of the name of truth at all, and pragmatist knowledge is indistinguishable from common empiricism.

A glance at the realities of physical science will, perhaps, make this clearer. Experiment is in the physical sciences what the pragmatist calls experience in the wider domain of all knowledge. By experiment on objects that come within the reach of our senses we are able to acquire ideas eminently useful. The impressions made upon the mind by a bit of polished amber woke useful ideas, which have their application in the agency which carries our news around the world. But this action and reaction of ideas and facts, even after they have been removed from our actual experience, go to show with no little force that ideas are chiefly useful because they are true in the sense that they depend upon facts. If useful ideas lead to the truth, it is first and foremost because they are founded on reality, and leave in the mind some impress of the objects with which they deal, and of the relations of those objects. Science imposes certain conclusions upon us because the facts print them upon our minds. Should these conclusions happen to be useful, in the sphere of new facts, it will be a confirmation of their truth. But they are useful because true, not true because useful. Prof. L. J. Walker† sums up this aspect in a few words:

> "Our thoughts must be determined by reality itself in and through sense-perception; and thus may we gain real knowledge, which, because it is real knowledge, is capable of leading to useful results."

The truth of the pragmatists is suspended in mid-air: it does not touch the earth, and its discoverers do not claim to have drawn it from Heaven.

Thirdly, pragmatism is a one-sided view of knowledge. It has acquired this defect, because it is an energetic reaction against certain other one-sided views. Against those who would have the intellect as the sole judge of all truth, pragmatism asserted

* "The Meaning of Truth," p. 195.
† "Theories of Knowledge," p. 555.

the rights of our volitional nature to have a say in the matter, by pointing out the practically true results of the "wish to believe." But if the intellect needs a corrective, much more does the will; and this corrective is not sufficiently supplied by pragmatism. Experience, coloured by what a man desires to be true, is a poor check on the vagaries of self-hypnotism.

Another reaction on the part of pragmatists takes the form of repudiating a too crude interpretation of the copy-book theory of knowledge. But, because what is real in nature cannot be perfectly reproduced under every aspect in the mind, the pragmatist has gratuitously assumed that "reality does not appear to us as it really is."* Ignoring the middle possibility that the concepts of the mind may be copies of reality, faithful as far as they go, *i.e.*, as representations, they are carried away by an idealistic prejudice. Hence they refuse to see any truth along that line, and repudiate the whole position of the realists.

With these tilts in violent opposition to a moderate realism the pragmatists are like men hopping on one leg, to use a simile of theirs. This is an unnatural mode of locomotion, however dexterously used. So pragmatism will always be a forced and unnatural theory of knowledge, whatever the ability of those who expound it.

Lastly, it is hard to see how the pragmatists of all schools can escape the charge of pure subjectiveness, which is fatal to knowledge as contrasted with fancy. This part of the subject has, I think, been splendidly developed by Prof. Walker†. He points out that, on the pragmatists' own admission, all pragmatic knowledge is tinged by their personal idiosyncrasies. On their hypothesis there are really no independent facts, but only facts transfigured by human interest; and the test of their truth-value only proves their usefulness, not their objectivity in the ordinary sense of that term. When we turn to the pragmatists and ask to see the objective data, which may save their knowledge from pure subjectivity, we are shown either "sensations," or "imminent deposits in the mind," or "conceptual parts of our experience." There is nothing to indicate that all these recondite psychological facts have any real dependence on data in the physical world. Unless the pragmatist establishes some connexion of the kind, we cannot be expected to share his feelings when he says that he

> "feels the immense pressure of objective control under which our minds perform their operations." ‡

Such feelings might easily be classed as delusions by those who do not share them. They certainly must lead to many delusive consequences, if the feeling of objective control is to be left in the vague terms in which the pragmatists are content to leave it.

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* Walker, p. 586.
† §§ 384-392.
‡ James, "Pragmatism," p. 233.

I cannot conclude this short sketch without a protest against a certain pragmatist assumption, namely, that the common-sense aspiration after truth is an impossible one. Prof. Walker has stated succinctly what this common hope is:

"What man wants, whether he be philosopher, scientist, or only one in a crowd, is a truth which shall tell him what reality is, truth which shall copy or resemble reality."

The pragmatist, however, proceeds to lecture the average man, as if he were a child, thus: You really cannot have what you want, because it does not exist; therefore take what I can give you—this pragmatic truth is as much as is good for you; so do not cry for the moon. The average man, alas! does not exist, so he cannot answer back. But the present writer will presume to usurp his functions, and say that he will take this good advice when the fundamental assumption on which it is based has been proved. So far no pragmatist has been able to prove that the kind of truth that man desires is out of his power. Common-sense may well claim to hold the field until some very strong argument routs it.

Moreover, in an age like ours we may well suspect the philosophy, which would supersede the democratic claims of common-sense by what looks dangerously like a régime of absolute monarchy in the intellectual world. In pragmatism, what appeal is there from the experience of the individual? No effective appeal that I can see.

Louis XIV. of France has been ridiculed for a dictum which was never his: "*l'état, c'est moi.*" It is a little late in the day to ask us to accept a philosophy which would practically enable any enquirer to say: "*La Science, c'est moi.*"

New Higher Oxides of Nitrogen.—Some four years ago F. Raschig showed that nitric hexoxide, N_2O_6, is a first product in the oxidation of nitric oxide by air or oxygen. On further oxidation nitric heptoxide, N_2O_7, is produced. The same investigator now announces in the *Chemiker Zeitung*, vol. 35, p. 1096, that the hexoxide is prepared by passing dry nitric oxide gas into liquid oxygen or liquid air contained in a Dewar vacuum vessel, when the new oxide separates first as greenish flocks and finally as a thick green paste. It is very unstable, and decomposes at temperatures slightly above the boiling point of oxygen, forming the blue liquid trioxide mixed with colourless crystals of the tetroxide.

THE OCCURRENCE AND DISTRIBUTION OF MANGANESE IN THE WESTERN DISTRICTS OF THE CAPE PROVINCE.

By W. Versfeld, B.A., B.Sc.

(Paper read before the Cape Chemical Society on the 25th August, 1911.)

Many attempts have been made to work successfully the various deposits of Manganese Ore that have, from time to time, been discovered in the Western Districts of the Cape Province. Few people have any idea of their wide distribution. They may be looked for anywhere between Worcester and Cape Point, wherever Table Mountain Sandstone is met with. Up to now all the important deposits have been found in Table Mountain Sandstone. At a few localities I have noticed small quantities in the granite and clay-slate underlying the sandstone. These are referred to later.

The earliest known occurrence of manganese in the Western Province is at a locality which is described on fairly old maps as "Manganese Mine," and is situated on the top of the Drakenstein Mountains some distance to the south-east of the town of Wellington. The mine is near the point where the Molenaars River changes its direction, at its junction with the Du Toit's Kloof Stream. This mine appears to have been worked at some time or other, as it has been opened up to a considerable extent, and there are still the remains of an aerial gear to be seen. A quantity of apparently excellent ore, ready for removal, is still lying at the mine. A drive had been made in the hillside, by means of which the ore could conveniently be brought to the surface, though why, under the conditions of the occurrence of the ore, it was not driven on the body of the lode (which admits of this) is a mystery.

Recently another attempt was made to work this deposit in connection with which the writer was employed to make a survey for the purpose of obtaining a mining lease from the Government, the mine being on Crown land. The syndicate obtained the lease of a large extent of ground, with the intention of disposing of their rights at the first opportunity, but owing, no doubt, to the inaccessibility of the mine, negotiations fell through, and it is presumed that the lease has now expired. This deposit appears to be as big as any that I have seen, and the contour of the surface admits of easy working, but the distance from the railway is a great disadvantage. The ore must be transported first up the Du Toit's Kloof valley and then down the mountain-side to Wellington or Paarl. If the proposed railway from Wellington to Goudini *via* Du Toit's Kloof is built, it will have to pass almost within a stone's throw of this mine, from which ore could be shot directly into the trucks.

Several miles to the south are some other deposits, one of which has got as far as the "mining lease" stage. This deposit is situated at the back of a mountain forming one of the spurs of the Drakenstein Range. This mountain is situated to the east of Paarl, and is easily distinguished by having a deep gully on the northern side, caused by a wash-away of soil. Several reefs are here met with running approximately east and west, but I am unable to state whether they have been opened up.

Other discoveries have been made on the slopes of the hills facing the Paarl Valley.

Near Gordon's Bay some very fair discoveries have been made on the Hottentots Holland Mountains, and a considerable amount of ore has been mined and exported. I am, however, unable to say how matters are progressing at present.

In the Breede River Valley, between Goudini Road and Breede River Railway Stations, a little to the north of the railway, some ore has also been found and worked.

Coming nearer home, there is an interesting occurrence of manganese on top of the Constantia Mountains, close behind the Government Wine Farm. This deposit has twice been taken up under a mining lease, but apparently very little has been done to test its richness. There are two or three reefs, the outcrops of which have been traced for a considerable distance. One reef has a very large proportion of limonite at the surface, while the other has good ore, which, as far as can be ascertained from the work done, is very pockety.

Further to the south-west I have observed occurrences of ore at several spots near Hout Bay. At one excellently situated locality a great deal of work has recently been done. The ore has been extensively mined, and a shoot has been erected into which the ore is introduced at several points, wherever mined, and run down to the sea. A considerable amount of ore has been shipped from this locality.

Recent discoveries have been made on Devil's Peak, in the neighbourhood of King's Battery, above Groote Schuur.

I am told that deposits are known at French Hoek, Bot River Mouth, and near Ceres, in the last instance the lodes occurring in Bokkeveld Beds. I have not personally inspected these three localities.

Nature of the Deposits.

All the lodes I have seen are very similar in their nature. They appear to have been formed by the filling of cracks in the Table Mountain Sandstone, and the impregnating of the Sandstone itself, in the neighbourhood of these cracks, by means of descending solutions. I am led to this belief by the fact that wherever I have observed the ore in the underlying granite it has been in very small quantities, filling very small cracks and forming impregnations of the granite, most likely after the latter had been somewhat decomposed and rendered porous. This can be observed on both sides of the hill known as Little Lion's Head, in the granite forming the base of the hill. At other spots where the granite is fresher the impregnations are wanting, but crack fillings are noticed.

An interesting occurrence is noticed on the slopes of Devil's Peak (Cape Town). In the surface soil, which is known to be underlain by Malmesbury Slates, there is an outcrop of a quartz reef, the country slate being quite hidden by the soil. This quartz has all its cracks and crevices filled with manganese ore—essentially a secondary deposit. The course of this reef will not necessarily coincide with that of the manganese lode, which I am of opinion will be found to be similar to the impregnations observed in the granite.

The more important lodes in the Table Mountain Sandstone are rather irregular in their occurrence. They form approximately vertical bodies of ore of very varying richness, this depending on the size of the apertures through which the original solutions passed. A large proportion of the ore is simply sandstone stained black, but this is easily distinguishable from the good ore. Consequently, though owing to the nature of the occurrence of the ore a very large amount of hand sorting is necessary; this can be easily carried out, even by natives.

It will be interesting to note how the composition of the ore varies at different localities. From time to time samples have been sent to Cape Town to be analysed. Formerly, when manuganic dioxide was the only important constituent of manganese ore, which was used only for the preparation of chlorine, the results of the analyses showed percentages of manganic dioxide and manganous oxide. Later, when the ore was used for steelmaking the analyses showed percentages of metallic manganese. Quite recently another use has been discovered for the ore, namely, the manufacture of a paint, which is claimed to possess superior qualities to those of other paints. In this case the percentage of neither manganese nor oxygen is of so much importance as the physical condition of the ore. The recent discoveries made on Devil's Peak are being put to this use.

A sample of ore from Hout Bay analysed in 1894 showed 80 per cent. of manganic dioxide, 5 per cent. of manganous oxide, and 9 per cent. of oxide of iron, besides other impurities. Another from Constantia showed 85 per cent., 12 per cent., and nil respectively. These must be considered as good ores both as regards manganese and oxygen contents, but unfortunately all the ores analysed do not show similarly good results. Samples from many localities have been examined, varying in manganese contents from 50 per cent. to next to nothing, but it is impossible to say if these samples were representative of the deposits from which they were taken.

A sample sent from Knysna gave 52 per cent. of metallic manganese and $1\frac{1}{2}$ per cent. of phosphoric oxide, while another from Namaqualand gave nearly 56 per cent. of metallic manganese. Unfortunately details are wanting as to the conditions of the occurrence of the ore at these two places.

The manganese industry seems to depend entirely on the facilities for shipping. The quality and quantity of ore, so far found, do not seem to warrant the expense of mining at all the localities where the ore has been discovered. If the deposits hitherto discovered are the richest existing in this neighbourhood, then I am afraid only those on the coast can be worked, unless the price of manganese goes up or the working costs go down. But there is no reason why far richer deposits—workable at any locality—should not be discovered.

Mineral Industry in Rhodesia.—Mr. J. P. Johnson's book, mentioned on a previous page (see p. 116), is intended to be a guide to the present position and future possibilities of the mineral industry of Rhodesia. After an introductory chapter in which the author gives a rapid glance at the geology of the country, he passes on to review the conditions under which gold is now being mined there, and very briefly describes nearly thirty Rhodesian gold-mining properties. The 1910 output had a sterling value of over $2\frac{1}{2}$ million pounds. A chapter is then devoted to the small mine industry, and the increasing prominence of other metals is next dealt with. At present chromium is one of the most important of these, but reference is also made to tungsten, thorium, tantalum, uranium, nickel, cobalt, copper, lead, zinc, vanadium, cadmium, mercury, tin and silver. The total output of silver to date is estimated to amount in value to £134,000. Chapter 5 is devoted to a consideration of South African tin deposits other than those in Rhodesia, special attention being given to the Potgietersrust and Rooiberg tin fields. Mention is made of a few small occurrences of tin in the Transvaal, and the chapter closes with a short account of the occurrences of tin near Cape Town on the farms Welbeloond, Langverwacht, and others adjacent thereto. Amongst non-metalliferous minerals, the chief position is given to asbestos, the others treated of being mica, magnesite, talc, graphite, and barite. Diamonds and coal have a chapter to themselves ,and it is recorded that the Wankie mine has hitherto yielded over 900,000 tons of coal, of which 180,000 represented the 1910 output. The Rhodesian yield of diamonds, mainly derived from the Roberts Victor occurrence, has aggregated over £30,000 in value, together with about £8,000 in other precious stones. The final chapter of the book consists of hints to prospectors.

AGRICULTURAL EDUCATION.

By Russell William Thornton.

Africa has been known and spoken of as the Dark Continent. It is undoubtedly dark in more ways than one, and enlightenment seems to have made slower progress in this country than in most other young and recently civilised countries of the world. Before we can teach we must have the material from which to draw the necessary information which is to be imparted to those whom we are teaching. Therefore it stands to reason that if we attempt to teach without information gathered from a solid foundation of facts in the country in which we live and work, such teaching cannot be other than sterile when the material is obtained in other countries, with conditions entirely different from our own. Before going into this subject I will take up the three forms of Agricultural Education with which we are confronted in South Africa to-day, and which it is our duty to carry out.

1. The instruction of young men who have completed their elementary education and who intend taking up farming.
2. The instruction of farmers or those who have already taken up the occupation of farming and are settled on the land.
3. The training of those who are to teach the first and second classes mentioned.

With regard to the youths who are to be trained as farmers, the first thing to consider is their elementary education. If this has been neglected, it is difficult to train such men for an occupation which requires more varied knowledge than any other in the world. The old idea of making the dunce of the family a farmer is rapidly disappearing, and it is the man with sound common sense, thoughtful, energetic, and the one who notes everything going on around him, that is likely to make a successful farmer. With regard to our present system of elementary education, to my mind this should not be tampered with in too severe a manner, but it is necessary that the boys should be kept in touch with Nature, and for this purpose text-books are really unnecessary, as no book is as suitable as Nature, from which they may be taught by actual ocular demonstrations with regard to plant and animal life, thereby making this teaching as interesting as possible. In fact, in our elementary education our aim should be not to teach agriculture, but to teach the boys to notice. If their interest is once aroused, they will look deeper for themselves. If this nature knowledge were taught in the correct manner, fewer boys would leave the farms and enter the towns on account of the attractions of town life. It is the entire break in their lives from the country to the town which is in no way mitigated that sends many of our best men into the already congested professions, such as law, medicine, etc. In the secondary schools the science taught is at present systematic, but it should be taught in a wider sense, as, for instance, with botanists and chemists. The chemist may be the finest analyst in the world and still be useless as an agricultural chemist, for the simple reason that though he makes the analysis correctly, he cannot interpret the result of his work in such a way as to be of practical value to the farmer. In the same way the botanist may be equal to any of his profession in the world, and yet it is within the bounds of possibility that he could not grow a crop equal to that grown by a third-rate farmer. The chemist must be trained as an agricultural chemist if he is to do agricultural work, and the botanist must have other knowledge than that of systematic botany, unless those men who are giving advice to practical farmers wish to bring disapproval upon themselves and on those following their professions. Science is one thing, knowledge of it another, and the application of that knowledge yet another, and in most cases the last is probably the knowledge that is lacked by many highly-trained scientific men.

Standard of Education.

The standard of education which students must have obtained prior to entering an agricultural school or college will and must always be determined by the standard of education in the country at the time. By this I mean that if the seventh standard is the standard on which students would be accepted at an agricultural school, then this is the standard that must have been attained by the greatest number of boys in the country who are likely to become good progressive farmers. Necessarily, if the standard of admittance is lower, the whole standard of the agricultural course must be lowered, as it would be impossible to teach advanced science to a student who has not had sufficient general education to grasp and assimilate the science expounded to him. Another point to be considered is the individual. Sometimes a sixth standard student will be vastly superior in every way, and make a better farmer than the seventh standard or matriculation man, yet a dividing-line must be drawn somewhere. If a student is admitted to an agricultural school or college who has not had sufficient education to assimilate the knowledge taught at the school, then those in charge are, in my opinion, defrauding the parents of their money, the student of his time, and bringing disrepute on the institution of which they have charge. The age limit is another question which should be carefully considered. The older the student, within reason, up to, say, 23 years of age, the better, in many ways, as he will have had more experience of life, and will understand more fully what work he intends taking up, and if any man in the country were given the choice of two men of equal merit in every respect, and the one were three years the senior of the other, he would, I think, take the senior man, as being the more experienced in the ways of life.

The College Work.

There are many points here which are difficult to decide, as whether that student will do better who has had practical experience prior to coming to the school than he who comes direct from the town to the college and learns the best methods, and so avoids the necessity of unlearning methods acquired which may, perhaps, not be of the best. Another point, and this, to my mind, the major one, is whether a student who has once been taught and knows how to do practical work—that is, who has been taught how to plough a straight furrow, set a plough, and handle one generally, shear sheep perfectly, etc.—should continue wasting his valuable time in doing this work over and over again until it becomes a mechanical operation, or whether he should turn his attention to the next most urgent practical operation which will help him in after life. The two years' course, such as we have in South Africa, is all too short to teach men thoroughly how to carry out practical work of different kinds which they will encounter on their own farms, and the shortness of the course renders it impossible for these men to keep at the same work for months on end if they have become proficient in this work. Yet there are many in this country who say that an agricultural school should be run entirely with student labour; meaning that men would have to continue the same work for months at a time when they are paying to be taught *all classes* of work. Practical work is an absolute necessity; every student must go through a complete course of it; and for this reason alone a two years' course is too short.

Experimental and Research Section.

This brings us to the all-important point with regard to all three phases of agricultural education to be dealt with in South Africa, namely, we have no South African data from which to teach. Unfortunately, agriculture does not stand alone in this respect. At present our teaching is from English and American text-books, and no teaching can be other than sterile unless we are able to teach South African facts, gathered under South African conditions by men carrying out the original research for this purpose. Therefore our colleges should have a sufficient staff of men, not only to teach the students, but to carry out the necessary research work to give them the facts to be taught to the students, as well as the facts to be taught to the farmers. Up to the present this has been impossible. The reason it will be interesting to ascertain. Probably men who could have done the work have had to attend to administrative details or constant teaching, which has rendered this impossible. Even such information as we have is widely scattered, and of no value whatever for teaching purposes, and has to be collected and prepared for the purpose; who can do this? Every man at present engaged in agricultural work is burdened to such an extent as to render this impossible, yet, unless we can teach South African agriculture to South Africans, we will never progress. Every other country is in advance of us in this respect, and the cause is not far to seek. For such work men are required, and the best men can only be procured by paying suitable salaries, and men are not taken because they are not willing to work for such salaries as a good man would refuse. People are even inclined to remark that agricultural schools should pay. Why this should be the case for agricultural schools, and not other schools, has never been disclosed. The college or school farm is a gigantic demonstrating laboratory, where everything is sacrificed to the student, as should be the case if we are carrying on our duty as it should be carried on towards the students placed under our charge. I do not say that the college will not, or cannot, pay working expenses and possibly something over, but what I wish to point out is that, if it comes to a point between leaving a standing crop of wheat to ripen, or that students should have to leave the institution without learning how to plough, I would say plough down the crop if no other land is available, but do not sacrifice your students for the sake of a few shillings, for the lack of which knowledge these students may, at a later date, lose thousands of pounds, and the country be far poorer than would have been the case if the initial cost of teaching had been increased by a few shillings. This is taking an extreme case, but conveys my meaning.

Teaching the Men Already on the Land.

This work may be carried out in several ways, to suit the several classes that are met. Some men will say science is not worth the breath wasted on expounding it; others take it as a panacea for all ills. The third are those who are ready to believe but desire proof—a desire which is felt by all men in any work undertaken. The man who believes that science can do everything is the most dangerous, as he takes it for granted that, given the analysis of the soil and of the crop which he will take from the soil, he will then know exactly what fertilisers to add to the soil in question to grow a perfect crop. This is a most dangerous fallacy. Farmers all over the world are, as a rule, conservative, and so they have a right to be, seeing that the knowledge they have secured has been won in the field of often bitter experience, and no one will blame them for desiring proof that what we teach will benefit them more than the knowledge they have gained by their experience. Therefore, the teaching to farmers should be done by actual demonstration work, showing them the advantage of the methods taught in pounds, shillings, and pence. Such a proof will carry more weight than all the lecturing and talking of half-a-dozen men for six months. Short courses for farmers at the agricultural colleges, in Dairying, Stock, Agricultural Engineering, etc., will be of great benefit, and will do more to popularise agricultural education than anything else, as, without the confidence of the farmer, we can never hope to progress with the schools and colleges.

The Training of Lecturers and Instructors.

This is a point that should receive, by all those interested in agricultural education, the gravest consideration. In the past we have drawn our entire agricultural staff for this country from other countries. Some of these men have proved as fine men as can be found anywhere in the world, but it is only natural that a man imported into this country takes a considerable time—and sometimes (though rarely) is unable—to adjust himself to his surroundings and the people of this country. There is no reason why we should not train our own men, that is, South Africans, for doing the work in South Africa. However, unless these men are to receive a training equal to that received in other countries, it will be better not to train them here at all. Points to be considered with regard to the training of teachers of agriculture are:—

1. Our present standard of education in South Africa.
2. The small number of our population.
3. The very few openings available for highly trained scientific agriculturists.

Our present general standard of education in South Africa is low; therefore, as I stated before, we must first cater for the greater number by training them as farmers. This does not, however, prevent our doing a very great deal of good to the few, by training them as experts, but it is quite impossible to think for one minute that a college can be established, and receive the necessary support for its establishment, if it were only going to turn out degree men. Success is rendered impossible for the reasons given above, namely:—

1. The Standard of Education.
2. The smallness of our population, and
3. The limited number of suitable positions for such men.

Assume for one moment that an institution were established for training degree men only. Such an institution would need a staff of highly trained lecturers, along with the initial expense, and also the expense of upkeep of the necessary buildings and laboratories, etc. Could this expenditure ever be justified at the present time? I do not consider that it could. What is possible, however, is for colleges turning out farmers to have, in addition to the two or three years' course, a four years' course which will enable men to qualify in certain subjects. As a model, I will take the Guelph College in Canada, which is turning out some of the best men in Canada and the United States to-day. This college has both a two years' and a four years' course, and students can pass from the two to the four years' course, provided that they obtain a certain standard of marks in all subjects in the two years' course, and that their standard of ordinary education is such as will be accepted by the University. Such a college has all the necessary equipment for turning out a two-year man, and also the necessary staff. A comparatively small number of men carry on to the four years' course, and the same lecturers, laboratories, etc., are used for training those men that specialise in certain subjects as in the general course prescribed for the two-year students. The increased cost, if any, is incurred only if the country calls for it by desiring advanced agricultural education; if the advanced education is not required, then the State incurs no additional expenditure. It therefore seems absolutely clear to me that the only way to train our future teachers is to train them through the medium of colleges as described above. These men would receive the full benefit of the research work being carried out by the staff, and also would receive a thorough practical training to start with, which would give them the connecting-link between science and practice, so absolutely necessary in a country like ours, which is starting from bed-rock. One or two of our present schools, if established on the lines indicated, will give us all the trained lecturers and men to be employed on research work that are required, and these men will have obtained their information by studying South African problems under South African conditions. If such a plan were followed, the time would not be far distant when South Africa would, without burdening itself with unnecessary expenditure, be in a position equal to that of other countries, and, if South African agriculture is to be established on a lasting foundation, then it must be established, in my opinion, on the basis described.

Mars by Colour-Photography. — M. Tikhoff has photographed Mars through coloured screens, and describes, in No. 42 of the *Mitteilungen der Nikolai-Hauptsternwarte zu Pulkowa* some of the results obtained. The "continents" appear very bright on the "red" photographs; much more so, in fact, than the south polar cap; while on the "green" photographs the latter is most intense. The "seas" are dark on the "red" plates, and greyish on the "green" photographs, the "canals" resembling the "seas," and being best seen by means of the "red" plates. It is concluded that the polar cap is not white, but greenish, and exhibits the optical properties of ice rather than snow.

Grape Seed Oil.—The oil obtained from the seeds of the grape, similar in type to that of the olive, has recently begun to acquire commercial importance in Italy. The seeds contain from 15 to 20 per cent. of oil, and the latter is now being utilised not only for lubricating and lighting purposes, but also for the manufacture of soap. France alone, it is estimated, could produce annually from 6½ to 10 million gallons of grape seed oil.

MODERN CHEMISTRY.—Little more than a decade has passed since the scientific world was stirred by the first discoveries of that striking series which has gone far to revolutionise modern thought on the subject of the constitution of matter. The researches called forth by these discoveries have, in their turn, opened up fresh vistas, and these again have resulted in further ramifications of research. The new conceptions of chemistry and physics have not only borne fruit in readjustments of scientific theory, but have also been accompanied by practical out-workings sufficient to content the most matter of fact utilitarian. But so swift has been the advance that present-day science has become as a sealed book, in respect of some of its basal principles, to many whose college curricula ended as recently as a dozen years ago. Most of the latter lack the leisure for continuous study needed to keep themselves abreast of the rapid bounds with which physical and chemical discovery is leaping forward. From the press there have already issued many publications dealing with various aspects of that advance; but even the student of the early nineties, who has not kept up his scientific study, now finds an unbridged chasm between his own knowledge of science and the stages arrived at in the latest printed records. Much greater is the difficulty for the general reader who never had any acquaintance with chemistry and physics, but in whom the marvellous developments of the last ten years have awakened an interest in molecules, atoms, and electrons. For such as these Dr. G. Martin, of Birkbeck College, London, has endeavoured to put into popular language some of the chemical conceptions which now find favour, and he has placed before his readers a few of the practical consequences of accepting these conceptions as working hypotheses, and of acting along the lines which they indicate.* Whether the author has invariably succeeded in clothing the intricacies of the loftiest branches of science in such language as to be intelligible to the populace, may be open to doubt. Probably such a result would be found impossible of attainment. Indeed many of the subjects dealt with are scarcely more capable of "popular" treatment than the Integral calculus or the Cartesian philosophy, and so the man in the street will unquestionably be puzzled to follow some of the lines of thought in all their details. The book nevertheless goes far in the direction of rendering the latent mysteries of chemical science comprehensible to general readers. The language used is less formal and conventional than in scientific text-books, and if, from a scientific standpoint, the sequence of subjects is somewhat disjointed, it is not more so than, for instance, in Humboldt's "Cosmos." Relative to the ability of the author to treat scientific problems with acceptance, it may be noted that his own researches in theoretical chemistry once

* G. Martin, B.Sc., Ph.D., "Triumphs and Wonders of Modern Chemistry," pp. xx, 358. 8vo, 1911. London: Sampson Low, Marston & Co., Ltd. 7s. 6d.

gained for him Prof. W. Ostwald's commendation that they were the work of "a quite unusual scientific imagination, taking the word in its best sense." So it goes without saying that in this book all who have followed recent scientific progress will find much to interest, and not a little to profit by. While the book is not altogether free from faults, it is stored with valuable information on a great variety of topics seldom brought before the general reader, including the Electronic theory; the proto-elements; Fournier d'Albe's speculations; the seepage of the ocean into the earth's crust; Arrhenius' theory of the inter-planetary spread of life; the swift succession of events within the atoms; the Nitrogen problem; the astonishing complexity of carbon compounds, illustrated by the resemblance between a single molecule of cellulose and the entire visible celestial universe; the increase of atmospheric carbon dioxide and consequent amelioration of climate; and numerous other aspects of chemical science, pure as well as applied. Dr. Martin occupies himself in his opening chapter with the theories of matter, the mystery of its constitution, and its relation to the Ether. The underworld of atoms is next considered, and, amongst other associated subjects, molecular motion in its inconceivable swiftness is dealt with. A short reference to the all but incredible speeds of the particles which build up the atoms themselves—speeds exceeding 100,000 miles per second—leads on to an explanation of the principle and functions of the ultra-microscope, that instrument by means of which it is asserted that the larger molecules, those of albumen, for example, have actually been rendered directly visible. The evolution of the elements—a phrase now received into common use—forms the text of the third chapter, and from this the author gradually passes on to stellar chemistry, with the inevitable glance at the future destinies of the universe, and at the compensational forces under whose laws it moves onward. By the ladder of analogy the descent from the infinitely great to the infinitesimally small becomes easy, and so, from stellar systems, we are led on—following the lead of Mendeléef and Sir George Darwin—to the consideration of atomic suns with electronic satellites, grazing impacts, like those which Prof. A. W. Bickerton has depicted with respect to crossing celestial bodies, serving as detailed illustrations to explain the course of events in chemical reactions between atoms—solar systems in ultra-micro-miniature as they are. In the next ten chapters of the book, water, hydrogen, air, oxygen, nitrogen, carbon, carbon dioxide, silicon, sulphur, and phosphorus are successively treated, and, although much of the information contained in these chapters is far from new, the facts are dealt with differently from the manner usual to chemical text-books. One instance of this is the statement, given on the authority of Erdmann (Lehrbuch der anorganischen Chemie) and Sir James Dewar (Presidential address to the British Association, Belfast, 1902), as an observed fact, supported by theoretical considerations, that, at a height of over sixty miles, the earth's atmosphere consists almost entirely (99.5 per cent.) of hydrogen, with a little (.5 per cent.) helium. Then, again, the energy produced in the formation of a single pound of water from oxygen and hydrogen is represented as sufficient to hurl a man to a height of over seven miles. The author's occasionally whimsical way of putting things has the effect of impressing scientific facts on the mind more indelibly than the usual conventional method can achieve. When dealing with sulphur Dr. Martin subscribes to the view that on the moon enormous deposits of sulphur exist, probably immensely exceeding any which occur on our earth, inasmuch as sulphur, the almost constant concomitant of volcanic action, will inevitably be found in the mighty lunar craters of over 100 miles across, where the stupendous scale of volcanic activity of past ages reduces the greatest similar terrestrial displays within historic times to absolute insignificance. The scientific imagination to which Prof. Ostwald referred frequently shows itself in the course of the book. At one time it is the description of a planet possessing great indigo-blue seas of ozone, with blue clouds and mists of ozone vapour in a dark blue sky, and possibly even a blue sun: at another it is seen in the portrayal of the final stages of our own earth, when all its atmosphere will have gone, and bergs of solid air float from the poles towards the equator, in seas of liquid air; when all sound has ceased, and stars at midday shine out of a coal-black sky upon a lifeless world. The volume closes with a chapter on fire, flame, and spectrum analysis, in the course of which the following incidental remarks occur:—

"It is no accident that those nations which lead in scientific research soon lead in everything else, be it wealth, trade, war, or peace. It is therefore much to be regretted that in England chemical research is greatly discouraged by a miserable system of public examinations which divert the energy of our rising youth, not into discovering new facts, but into absorbing by bookwork facts already discovered by others. . . . How different a system is employed for training the youth in Germany and America! In these countries chemical research pays the student in that it helps him to attain his diploma and obtain a post afterwards in which he can earn his living. He can do research while actually studying for his degree—a thing quite impossible to do in England because of the incessant examinations, intermediate and other, which are always looming on his mental horizon. The German student . . . usually spends his time in mental peace, doing research work under a distinguished professor as well as studying and attending courses of lectures to qualify for his final examination. The final result of this system is seen in the magnificent and flourishing chemical industry of that great country."

Amongst those whom the author thanks for assistance rendered in the publication are Sir William Crookes, Mr. F. Soddy, Mr. J. E. Gore, and Sir William Ramsay.

TRANSACTIONS OF SOCIETIES.

South African Institute of Electrical Engineers.—Thursday, October 19th: Mr. J. H. Rider, V.P.I.E.E., President, in the chair.—"The troubles of cables": A. E. **Gibbs**. The author gave an account of some of the faults and other troubles that he had experienced in connection with cables, and described the methods for locating these. In this connection he discussed the advantages and disadvantages of lead covered and bitumen covered cables, and the various methods of laying and joining.—Thursday, November 16th: Mr. J. H. Rider, V.P.I.E.E., President, in the chair.—"Fixation of atmospheric nitrogen by electricity": Dr. W. **Glucksman**. The importance of the nitrogen problem and its special importance for South Africa, where nitrogen is needed for agriculture and nitrogenous explosives for the mines, was first emphasised, and after referring to the principles of fixation methods, the author briefly dealt with the several processes introduced by Bradley, Lovejoy, Kowalsky, Moscicky, Birkeland, Schönherr, and Pauling.

Chemical, Metallurgical and Mining Society of South Africa.—Saturday, October 21st: Mr. H. A. White, Vice-President, in the chair.—"Notes on high duty gravity Stamp Mills": P. N. **Nissen**. A description of recent improvements in the design of gravity stamp mills, with illustrations of the capabilities of the improved stamps and of the advantages to be derived from their installation.—Saturday, November 18th: Mr. E. J. Laschinger, Vice-President, in the chair.—"Accidents in Transvaal Mines": J. **Chilton**. The author said that the Transvaal Mines have the highest accident rate of any mining district in the world, and that on every full working day in 1910 three persons were killed and six injured. The Transvaal mines death-rate was 31.5 per million tons raised, as compared with 4.5 in England. Accidents due to defective plant were diminishing, but those resulting from inherent danger in the work itself were increasing. More accidents resulted from falls of ground than from any other cause, and it has been a steadily increasing cause for the last seven years. The author concluded by advising the appointment of roof inspectors and the systematic timbering of stopes.—"Practical applications of the specific gravity flask": H. **Stadler**. The author showed how a wide-mouth open flask, with a true ground edge, could be of great practical use in (1) determination of specific gravity of solids, (2) determination of specific gravity of pulp, (3) determination of weight percentages of dry solids and water in pulp, (4) tonnage measurements of total pulps and of dry solids in pulps, and (5) relation of flowing quantities in classifiers.

South African Institute of Engineers.—Saturday, November 25th: Mr. F. H. Davis, President, in the chair.—"Notes on cams for Stamp Mills": G. M. **Adams** The author showed that the stresses on the cam shaft could be greatly reduced by increasing the period of initial acceleration, that it would probably be imperative to employ means of reducing those enormous stresses owing to the tendency to use heavier stamps. Methods were given of arriving at rules and formulæ for determining the proper strength of cam shafts, bearings, etc.

NEW BOOKS.

Fyfe, H. Hamilton.—*South Africa to-day: with an account of modern Rhodesia.* London: G. Bell & Sons, 1911. Demy 8vo., illus., 9s.

Kassner, Theo.—*My journey from Rhodesia to Egypt, including an ascent of Ruwenzori and a short account of the route from Cape Town to Broken Hill and Lado to Alexandria.* London: Hutchinson & Co., 1911. pp. xiv, 310. 9 in × 5½ in. Maps and illus. 12s. 6d.

Christy, Cuthbert.—*The African rubber industry and Funtumia elastica.* London: J. Bale, Sons & Danielson, 1911. pp. xvi., 252. 9 in × 5½ in. Maps, illus., and diagrams. 12s. 6d. nett.

CHEMISTRY AND CRYSTALLOGRAPHY—A NEW SUGGESTION.

By James Moir, M.A., D.Sc., F.C.S.

If my readers will cast their minds backwards to the physical text-books and lectures of their youth, they will recollect a certain mathematical abstraction called a *particle*. What exactly the mathematicians meant by it, I was never able to fathom. In those days Chemistry was the Cinderella of the sciences—despised at the Universities, and as unknown to the so-called "educated man" as Chinese—consequently no one amongst the mathematicians worried about the fact that the neglected science also used a similar fundamental unit of matter called a molecule, or knew that Chemistry could go beyond the molecule in most cases and find it made of an arrangement of atoms.

Crystallography therefore had no possible explanation except that of a geometrical arrangement of the mathematician's "particles": no one knew if the "particles" of common salt were simply molecules, or much bigger aggregations of the composition $(NaCl)_x$. The simple-minded were content to ascribe the shapes of crystals to Divine design—like the cells of the honeycomb, to take a more familiar case of misplaced enthusiasm.

About six years ago a series of epoch-making papers from the pen of Pope and Barlow began to appear, in which, by building together spheres of different sizes for the different types of element, these authors succeeded in depicting the innermost structure of the crystal-aggregate. Unfortunately, the papers are not only devoid of literary grace of any sort, but have not even the merit of ordinary scientific lucidity: most of the sentences are Ciceronian in length and Kantian in obscurity; consequently the importance of the work is likely to be overlooked unless another Huxley arises to interpret the scheme—which, in my opinion, is just as important for science as the Darwinian one.

The present writer is no Huxley, and must therefore be content with friendly criticism, believing that Truth only grows by the friction of mind on mind.

The main assumption of the Pope-Barlow hypothesis is a sufficiently startling one, *viz.*, that valency is a function of the size of the atomic sphere: thus if the hydrogen sphere has unit volume, then sodium, and chlorine, and even iodine and cæsium, have also atomic spheres of much the same size as hydrogen; whilst oxygen has a sphere of volume 2, and carbon a sphere of volume 4. This conception, whilst totally at variance with our knowledge of valency as a series of forces varying in *direction* rather than in magnitude, is not altogether incredible. Lately, however, Pope has complicated the question by finding that silicon and oxygen have nearly the same size of atomic sphere in quartz and tridymite; and as oxygen is certainly not tetravalent in these substances, silicon must be assumed to be divalent—that is, if valency really depends directly on size of sphere. This conception of divalent silicon seems, however, to be quite beyond belief; and despite the marvellous results obtained by Pope among the organic compounds, I am compelled to believe that the fundamentals of the theory must be modified to a certain extent, so that our present ideas of valency shall not be too much violated, nor our knowledge of atomic volumes set at naught.

The suggestion which the writer wishes to put forward is one which, like Pope's, must shock the chemist of the older generation; but since the latter is gradually becoming accustomed to the idea of the composite nature of the "elements," he will not be altogether unprepared for this further attack on the last generation's creeds. Briefly, my new suggestion is that the chemical 'equivalents' have in most cases a real and separate existence, and that their atomic spheres (equivalent-spheres) are approximately all of the same size. Thus the element carbon is (in my opinion) a tetrahedral arrangement of four equal spheres, each of atomic weight 3 and of volume very slightly greater* than that of the hydrogen atom: oxygen is to be represented as a juxtaposition of two equal spheres of atomic weight 8: silicon as a tetrahedral arrangement of four spheres each of atomic weight 7.08: glucinum is to be taken as two spheres of atomic weight 4.55 each, and so on. (On the other hand, certain elements, such as nitrogen and boron, both very similar to carbon, are probably *heterogeneous* assemblages of spheres of different atomic weight, though of approximately the same size†.) I may point out that the fundamental *directive* power of valency follows at once from the position of the spheres.

This theory at once disposes of the silicon difficulty, since the fundamental spheres now become nearly equal: in the silica molecule, we would have a central group of four spheres each of weight 7, in the hollows of which are four spheres of weight 8 to represent the two atoms of oxygen. The aggregate would have the required two crystal forms.

Similarly, water becomes a tetrahedral arrangement of 2 H and 2 *o* ($o = 8$), which brings out an analogy to H_2F_2. Oxygen *gas* becomes a *regular* tetrahedron of *o*'s. Caustic soda would be a similar case, which would also have the interest of being a return to the formulation of fifty years ago; thus Na*o*.*o*H recalls NaO + HO, and also the intermediate stage of $Na_2O\ H_2O$, still used by agricultural chemists and other backwoodsmen. It should be noted, however, that my scheme doubles all the old formulæ, *e.g.*, sodium oxide is Na_2o_2 in place of NaO. Similarly, alumina would become $(Alo)^6$, where $Al = 9$ and $o = 8$‡.

* As a first approximation to the relative volumes of the equivalent-spheres, I suggest the sixth or the eighth root of the atomic weight. This explains the considerable difference between the H and Cl spheres and the smaller difference between those of Cl and I.

† An analogy between Li and NH_4 can, for example, be made by assuming that Li is ZH_4, arranged as a square pyramid where Z is the sphere of atomic weight 3.

‡ Thus valency becomes simply the number of equivalent-spheres *of the same sort* joined together in a crystal-aggregate.

If it be objected to the scheme that the equivalent spheres ought to be separable, the assumption may be made that such central aggregates of spheres are *slightly* coalesced. This idea is the same as Pope's conception of the elimination of interstitial space between his spheres. Another objection which seems at first more formidable is that my carbon tetrahedron of spheres occupies too much bulk to take the place of Pope's carbon spheres (which have the same volume). The circumscribed sphere to my tetrahedral arrangement has a radius $= (1 + \sqrt{\frac{3}{2}})$ times the radius of the "equivalent-spheres" (the volume being

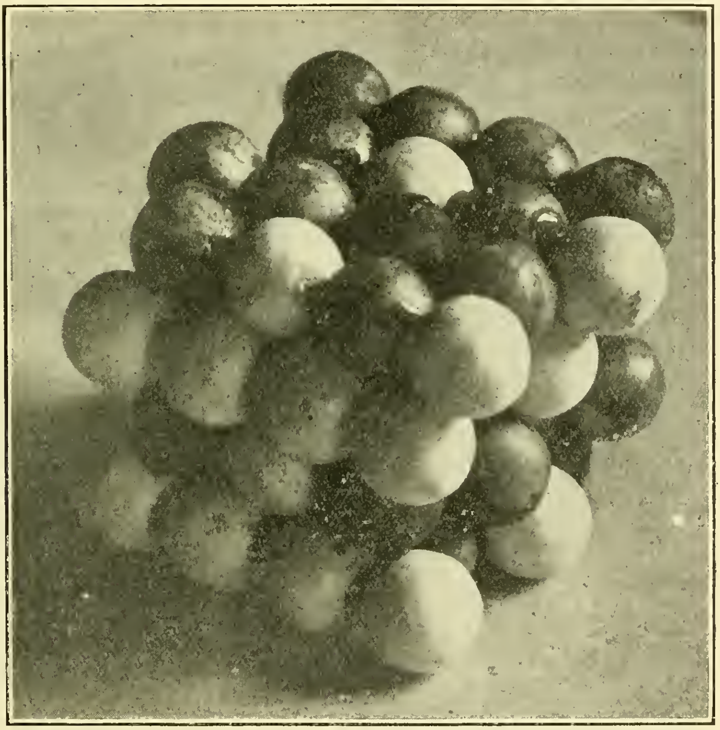


Fig 1.—Aggregate of methane molecules *

11 times that of a sphere), and it might be supposed that the assumption of half-sized equivalents (*i.e.*, semi-valent) would explain the facts better; but as a matter of fact the hollows between these equal spheres allow of such exact close packing that the tetrahedron of spheres above described seems to represent the carbon atom even better than Pope's scheme does.

It will be desirable to show how this theory fits in with some of the concrete cases discussed by Barlow and Pope. Taking methane first, and examining Pope's assemblage which represents it, we find its unit to be a cube of carbon spheres

* In the figures the dark spheres represent Z of atomic weight 3

with the inscribed tetrahedron of 4 hydrogen atoms (turned through 180° round the cube-diagonal), the whole system being then distorted by compressing four of the carbon spheres round a diagonal point in upon one of the central hydrogen spheres, and expanding the other four carbons so as to fit in the other three central hydrogen spheres. Now when equal spheres are in cubic order, each cavity is slightly smaller than a sphere *viz.*: $(8 - \frac{4\pi}{3}) : \frac{4\pi}{3}$), and the density of the assemblage is $\frac{\pi}{6}$, *i.e.*, 52.4 per cent. of the space is

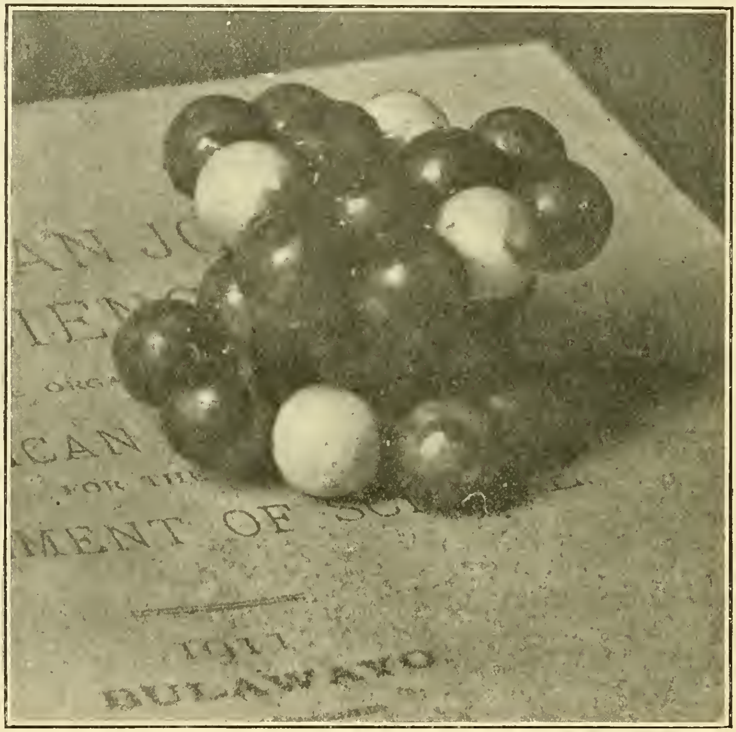


Fig 2.—Benzene Model.

occupied. It follows that the introduction of the hydrogen must make Pope's final assemblage looser than $\frac{\pi}{6}$, since both the carbons and the four hydrogens together have a separate density of $\frac{\pi}{12}$; consequently much compression will be required to eliminate the interstitial space. My own arrangement, on the other hand, is essentially the same as the close-packed arrangement of *equal* spheres described by Pope in earlier papers, subject only to the modifications introduced by (1) having the spheres arranged in two sets of tetrahedral order (one representing C and the other set H_4), and (2) the supposition that the $\frac{C}{4}$ ($= Z$) spheres are slightly larger than the hydrogen spheres. The new assemblage can be divided into practically exact tetrahedral arrangements to represent gaseous CH_4 ($= Z_4H_4$ where $Z = 3$), in which the distance between the centres of the hydrogen spheres is exactly 5/3 of the sphere-diameters (all assumed equal), and in other respects it seems to be very similar to Pope's arrangement, though somewhat more closely packed.

The case of benzene is somewhat similar. Pope's model consists of alternate layers of 6-membered rings, each C_3H_3 and alternately reversed.: the carbons in each layer are separated by hydrogens, but each carbon is in contact, zigzag fashion, with two carbons from the other layer. There is a central hexagonal hollow (a tube in the aggregate). My scheme for benzene consists of three layers, of which the middle one is a hexagonal of Z spheres, and the other two are Z_9H_3, one being reversed with regard to the other. The structure has an 18-sided hollow in the middle, which does not form a tube in the aggregate. The relationships of the ortho-, meta- and para-positions appear to be the same as in Pope's scheme.

Insect Borne Disease.—The Rhodesia Scientific Association's Gold Medal for an original paper advancing the knowledge of the transmission of any insect-borne or arachnid-borne disease affecting Rhodesia, has been awarded to Dr. Edward Hindle, A.R.C.S., F.L.S., Beit Memorial Research Fellow, Magdalen College, Cambridge, for his paper on "The transmission of *Spirochæta Duttoni*."

Ostrich Farming in Germany.—The *Journal of the Royal Society of Arts* (Vol. 60, p. 128) briefly describes the development of the Hagenbeck ostrich farm at Stellingen, near Hamburg. The farm was founded three years ago and has increased rapidly in size and importance. The proprietor's theory that the ostrich would grow a heavier crop of feathers in colder countries than in his native tropics has been experimentally proved correct. The Stellingen farm holds two Cape female birds, two each from Senegal and Somaliland, and eight from the Blue Nile country, the last being considered the finest birds, and belonging to a species that is becoming very rare. The proprietor possesses a farm for similar purposes in German-West Africa, and is establishing another near Trieste.

THE MASARWAS AND THEIR LANGUAGE.

By Rev. S. S. Dornan, M.A., F.G.S.

I. The People.

The people called Masarwas by the Bechuana, for amongst themselves they are called Hiechware, or people of the country, inhabit the Bechuanaland Protectorate, the Kalahari, and the portions of Southern Rhodesia bordering on those countries. Livingstone, in the fifties of last century, found them in the northern and western parts of the Protectorate, and remarked upon their large physical proportions, quite a contrast to the other Bushmen of the Kalahari and Bechuanaland. The same remark was made by Mackenzie some years later, who also remarks upon the change in their colour from that of the ordinary Bushmen. The Bechuanas called, in the time of these two travellers, all Bushmen Masarwas indiscriminately, distinguishing, however, between them and the Bakalahari, who are degraded Bechuanas, and yet live under much the same conditions. This applies at the present time, as the writer heard Bechuanas apply the term Masarwas to other Bushmen, always in a tone of the greatest contempt. "The Bushmen are snakes," "The Bushmen are inveterate thieves," are quite common expressions amongst the Bechuanas, and they simply cannot understand why anyone should take the least interest in such vermin, or see anything to admire about them. For a long time I could get very little information about the people. What little I got was mainly derived from two Bechuanas, who had been cattle herds in their youth, as everyone is amongst the Bantu tribes, and had spent a considerable time with the Masarwas, and had thus acquired their language. Eventually I overcame the reluctance of the Bechuana masters, and was allowed free access to the Masarwas.

An interesting question at this stage is: What is the meaning and origin of the name Masarwa? Amongst the Basuto the Bushmen are called Barwa, a name which may mean "men of the south," from "borwa," meaning the south, or what pertains to a Bushman. No other term is applied to them so far as I know. Amongst the Kafirs and Zulus this word assumes, according to the law of consonantal change in Bantu, the form Abatwa, a name of very widespread occurrence amongst the various dialects. That this is no recent designation of the Bushmen by others is proved from the fact of its occurrence on an old map of South Africa, the region round Delagoa Bay and northwards being so named. It has been suggested by a friend of mine that Masarwa is really a pluralised form of Serwa, which is the designation for the language of the Barwa, and that this occurred through some misunderstanding or misinterpretation. It would then mean the people who speak Serwa. If such is the case, it is certainly a new development in Bantu, and thus the term Sesarwa, or the language of the Masarwas, is a word with a re-duplicated prefix. I do not advance this explanation as anything more than a probable one. Apart from it, I have no other to offer. Amongst the Amandebele, they are called Amasile, which is simply the Sindebele form of the Sechuana Masarwa, there being no *r* in the Sindebele language.

With regard to the origin of the people themselves, most authorities agree that they are a cross between the original Bushmen and some Bantu tribe. I should not like to say that the Bechuanas were the tribe in question. I do not see any evidence of that. I am inclined to favour some tribe nearer the West Coast.

In personal appearance the Masarwas are tall, about 5 feet 6 inches and over, and well formed; quite as tall as the Bechuana, amongst whom they live, if not taller in some cases. Their colour is very little lighter than the latter, and the body well nourished. Some of the women are small, but all are plump so far as I have seen, and there is a notable absence of the wrinkled skin to be seen in most Bushmen. The typical Bushmen are small, light yellow in colour, with scanty hair, whereas the Masarwas are large-boned, well formed, and have abundant hair, just like the other Bantu tribes. The face is flat, and the nostrils wide and prominent. The eyebrows are pretty well marked, and there is one feature common to both men and women, the retreating lower jaw. This is a Bushman characteristic. Another striking characteristic is the hollow back in both sexes, and steatopyga in the women. This is quite marked, even in young girls. The legs are thin, and well-developed calves conspicuously absent amongst such specimens as I have seen. On the whole, in personal appearance the Masarwas have inherited more of the Negro than of the Bushman type.

Their clothing consists of a moderate-sized piece of skin round the loins. Sometimes even this is dispensed with, and a small piece of skin threaded on a piece of sinew, and passed between the legs and tied in front. Others wear mantles of skin over the shoulders. Where they live in large villages of the Bechuanas, they adopt to some extent European clothing, though seldom wearing trousers, being usually satisfied with a jacket, or preferably an overcoat. Both sexes wear ornaments of various kinds, such as strings of beads, berries, or small bones round the neck, and pieces of bone, metal, or wood in the ears. They are very fond of collecting tin-openers, such as are supplied with sardine tins, and using them as earrings. I have seen a man with as many as four of these in each ear. Neither sex wear any headgear, even in the hottest or most inclement weather. Their occupations, when not employed as herds by their Bechuana masters, are hunting and capturing game. At this they are very expert, and use bows and poisoned arrows. The poison is prepared from the juice of a certain bulb, mixed with snake poison. It is reddish, not unlike coffee in colour, and of a jelly-like consistency. When smeared on the arrows, it is set in the wind, and soon dries. There may be other ingredients than those specified in its composition, but I am unable to ascertain them. According to the testimony of all who have employed them, they are most expert game-trackers.

A little coarse pottery is made, but most of their culinary apparatus consist of ostrich eggs for carrying and storing water. These are transported, when on the march, in a net slung over the shoulder, and are carried by the women. A few sticks are also carried to produce fire, when an animal has been brought down.

Their habitations consist of a few branches of trees stuck in the ground, tied together at the top, and covered with grass. Such a shelter keeps out the wind and a passing shower, but when a spell of wet weather sets in they are obliged frequently to shift their habitations, as they get saturated with water. I have never heard of their living in caves, nor do I know of any such caves, either at present or recently in occupation. I have repeatedly inquired if they practised the art of painting, as the other Bushmen do, but I was always met with a denial—whether from want of desire to impart information, or whether they never possessed the art, I cannot say. They know of other Bushman paintings at places I mentioned to them, such as the Matopos, but they always said that their tribe did not paint, at least not now.

They do not practise circumcision—at least this was the testimony of those I questioned; but I also learned that some of them had been circumcised who lived amongst the Bechuanas. Whether this meant that they had to conform to the Sechuana practice or not, I cannot say. Neither do they, so far as I have seen, cut off any of the joints of the fingers.

When death came to men and women in former times, they simply threw the body outside the encampment to be devoured by the hyænas and vultures. Now, most of those who are employed by the Bechuanas bury their dead in a similar manner to their masters; but I could not ascertain if they practised any of the Bechuana ceremonies at the interment.

They have great faith in their dice. Nearly every man, whatever his occupation may be, carries a set, and consults them upon all occasions of importance. Apart from a belief in magic and witchcraft, their religious notions are hard to define. They believe in a Spirit which they call *Zimo*, a modification of the Bechuana name for God, *Modimo*. They say He controls the storm, and He appears to be little more than the storm demon. They have also names for different constellations, and believe that some of them are animals—for instance, the Southern Cross is *gaabe |khaine*, the Giraffe. Christianity has made practically no impression upon them, partly, no doubt, owing to the prejudice against their being Church members in the eyes of the Bechuana masters.

Altogether they are low in the scale of intelligence, and their life is a hard one, not one calculated to improve them. Many of them are to-day employed by the Bechuanas as cattle herds. They are given charge of the herds by the chiefs, and take them to the cattle posts, and are responsible for the cattle. They are permitted to take the milk of the cows, and have sometimes a few goats given them for their hire. Naturally, stealing from their masters is not infrequent. They are said to make good herdsmen, and on the whole prove faithful to their charge. Formerly they were treated with great cruelty by the Bechuanas, and were hunted and shot down mercilessly. Commandoes were regularly sent against them. On one occasion twenty were shot down at a trader's wagon, and he dare not interpose to save them, and this was a common occurrence, as the early missionaries and traders testify. Since the conversion of a large portion of the Bechuana to Christianity more humane methods have been adopted. Nevertheless, in many cases it must be admitted that the treatment to-day is very far from satisfactory, and that they are practically slaves. Their masters pay the hut-tax for such as they employ, though there are exceptions to this custom.

II. Their Language.

The language of the Masarwas is related on the one hand to the other Bushman dialects round about it, and on the other to the Korana and Namaqua languages. It seems to stand about midway between the ||*aikwe* and *Tsaukwe* dialects as given by Passarge, at least as far as the individual words are concerned. It is only remotely related to Namaqua. In the grammar there is a resemblance, for example, in the regularity of the formation of the plural in the verbal forms and in some of the individual words. Out of fifty of the most common words in Sesarwa, only six bore any resemblance to the corresponding words in Namaqua; thus it can confidently be said that the two languages are no nearer than English and German. Mr. F. C. Selous, in his "Travel and Adventure in South-East Africa," p. 106, has the following paragraph:—

"In 1873, when hunting in the Linquasi district to the west of Matabililand, we saw a great many Masarwas (Bushmen), and noticing that their language, full of clicks and clucks, and curious intonations of the voice, was similar in character to that I had heard spoken by the Koranas on the banks of the Orange River in 1871, I asked John if he could understand them, but he only laughed and said, 'No, sir.' During the next two years, however, John had a lot to do with the Masarwas, and one day towards the end of 1874, as we were returning from the Zambesi to Matabililand, I heard him conversing quite familiarly with some of these people. 'Hullo, John,' I said, 'I thought you told me you couldn't understand the Bushmen?' 'Well, sir,' he answered, 'At first I thought I couldn't, but gradually I found that I could understand them, and that they understood me; in fact, I can say that with a few slight differences, these Bushmen speak the same language as my people (the Koranas) on the Orange River.'"

Again, he says:—

"A Griqua family, too, the Neros, who have for many years been living in Matabililand, all speak Sesarwa (the language of the Masarwas) with perfect fluency, and they have all assured me that they had no difficulty in learning it, as it was only a dialect of the Korana. . . . . Altogether I am inclined to think that the Masarwas were originally a people allied in race to the Koranas and Hottentots, but that from constant infusion of foreign blood, brought amongst them by refugees from different Kafir tribes, they have to a great extent lost the physical characteristics of that race, though they still retain their ancient language almost intact."

Over against this we may set the testimony of Mr. C. C. Clements Vialls, who has spent over twenty years amongst the Masarwas. The latter thus writes, in an article in the *African Monthly*, for December, 1908:—

"They appear to be possessed of a very small degree of intellect, but an abnormal degree of instinct. Their vocabulary I do not think consists of more than three hundred words, and is a series of clicks, like the Hottentot, but quite unintelligible to that tribe: Either because they are more reticent than other natives, or else have no capacity of retention, I have so far been unable to extract from them, or through the Bakalahari (who have been in contact with them from a remote past) any national traditions.

"One pecularity I have noticed is that among them there are some with a much darker skin, almost black, of whom the men all have beards or tufts of hair on the face, and a good crop on the head, whereas the light-skinned or yellow ones have no beards or hair on the face, and a very sparse quantity on the head."

The truth lies between these two views. Taken together, they sum up the morphological and linguistic facts tolerably well. The vocabulary is much larger than Mr. Viaills supposes. I have collected 1,750 words, and I am quite sure that I have by no means exhausted the list. This does not include derivatives or verbal forms, which would bring the list up to 2,000 words. With regard to the closeness of the relationship of Sesarwa to Korana, as indicated by Mr. Selous, I regret that materials sufficient in the latter language are not in my possession to decide the point. If the relationship is not closer than between Sesarwa and Namaqua, Mr. Selous is in error in describing it as a dialect of Korana. As the question stands at present, all that can be said is that they both belong to the same family of languages, and there would be no difficulty in any person who knew Namaqua or Korana picking up Sesarwa.

There are thirty-one letters in the alphabet, and four clicks which do duty as consonants. Of these there are five vowels, *a, e, i, o* and *u*, each of which has two sounds, the open or long, and the close or short. Diphthongs do not exist in the language, and when two vowels come, the first is short and the second is long, both being thus sounded separately. There is no F in the language. The clicks are four, possibly five, in number, and are termed the dental, palatal, lateral and cerebral clicks. They are formed by pressing the tongue against the front teeth, the palate, the side of the teeth and palate, and by closing the faucal region with the tongue. There are various modifications of these harsh sounds, such as aspirating and hardening, or softening, but they are not distinctive enough to merit detailed description, and can only be detected by familiarity with the language. These clicks are interchangeable to some extent, as the dental and lateral, or dental and cerebral, but seldom the palatal and cerebral, examples of which are |*gao* and ||*gao*, a snake, ||*gham* and |*kam*, the sun, |*khaine* and ||*khaine*, a star, The accent is always on the final syllable of a word, and is very marked, the stress rising towards the end of the word, as *guirihè*, to perish, *amatho*, a small pot, *gabè*, a giraffe. The union of accent and stress has rather a pleasing effect on the ear.

The great majority of words in the language are dissyllabic, a number trisyllabic, and a very few polysyllabic, most of them evidently derived from monosyllabic roots. Most of the words end in a vowel, the remainder in a nasal *m* or *n*, but never in any other consonant. In this respect Sesarwa resembles Sechuana and the other Bantu tongues round about, but otherwise there is no resemblance between them, except loan words, of which a considerable number exists in the language, principally from Sechuana.

There are no prefixes in the language. Most of the relations of time, place and number are expressed by the addition of suffixes, or by the use of separate words. Some of these, especially the pronouns, are prefixed, not postfixed, but are not prefixes in the proper sense of that term.

There are but two numbers in Sesarwa, singular and plural. The plural is expressed by the addition of the suffix *re* or *ra*, as *koha*, a zebra, *kohare*, zebras, *kham*, a lion, *khamre*, lions. Borrowed words usually take the suffix *ra*, as *koko*, a fowl, *kokora*, *sepere*, a horse, *seperera*, horses. If, however, the word ends in *i*, as *gaieti*, a servant, the form assumed is *gaietiare*; *shotsi*, a dreamer, *shotsiare*. It would appear that here we have the original form of the plural of which *re* is a worn-down form, while *ra* is a later development, especially as it occurs most largely in loan words, and in words expressive of things not familiar to the old Bushman life. Reduplication to form the plural such as is given by Bleek, Bertin and Planert in their grammars of the various dialects known to them do not occur in Sesarwa. The plural is always formed by the above suffixes, and never, to my knowledge, in any other way.

Abstract words are very rare in the language. Where such have to be employed, they are formed from the infinitive mood by the addition of the suffix *o*, as ||*khaba*, to form a habit, ||*khabao*, a habit. But it is doubtful whether such forms are really abstract nouns or not, as *moo*, sight, and many others that might be named, are the same as infinitive mood.

Gender does not exist in the language, at least, in the way it can be expressed in Namaqua. Thus Bleek's contention that Bushman would turn out to be not a sex-denoting language is correct, so far as Sesarwa goes. The gender can only be inferred from the context. The agent is expressed by the suffix *thi*, as ||*gan*, to build, ||*ganthi*, a builder. There is no article in the language, nor anything corresponding to it. Thus *aba* may mean a dog, or the dog, *du* an eland, or the eland.

There are no cases in Sesarwa. The genitive, dative or accusative can only be expressed by the aid of prepositions, or inferred from the structure of the sentence, as: *Hie cha*

|*kamnye koharc khai,* The Bushman has two horses; ||*gaicha jubera crekwa gamoc,* The cattle of the Chief are lost; *Aba ka chikwa choo karohwa,* I bought a dog for the boy. There is a kind of locative case, as *juwa,* in the house, *jinao,* at the well, *hiimo,* in the tree, though it is doubtful if these forms are really locatives.

Adjectives, properly so called, are few in the language. The same word may be used as a noun or as an adjective, as |*kao,* new or newness, *zio,* foolish or foolishness. The adjective undergoes no change when connected with the noun, as ||*koo hii,* a big tree but if we wish to use the adjective predicatively we must say, *hii ckwa* ||*koo,* the tree is large, *jube ckwa* |*tie,* the ox is white, whereas |*tie jube* would mean a white ox. The adjective does not assume the plural form, when connected with a plural noun, either attributively or predicatively, as |*tie jubera,* white oxen, *jubera crekwa,* The oxen are white.

The comparison of adjectives is exceedingly clumsy, and similar to that in Bantu. If we want to say, This stone is hard, we must say *e*||*gwa e karii*; but if we require to say, This stone is harder (than that one), we employ the form *e*||*gwa e karii* ||*gwa ii khaisa,* which means, This stone is harder than that stone; and for the superlative the form *e*||*gwa e ho se karii,* This stone is hardest of all stones. Sesarwa, in this respect, resembles both Namaqua and Bantu. Numeral adjectives exist only up to five. Beyond that many are spoken of. I have heard the expression "two hands and two feet," but not in the sense of exact numeration. I do not think the average Masarwa counts beyond five except in Sechuana.

There are three persons, singular and plural, in the language. The forms are the same for masculine and feminine. In the pronoun of the first person an interesting alternative form occurs in the plural. The ordinary form *Tse* means men and women indifferently, but the form *ka* is a special form meaning men only.

Other pronouns, such as relative, interrogative, possessive, distributive and indefinitive occur. The forms for singular and plural are generally the same.

Verbal forms are remarkably well developed in the language of the Masarwas. There are two voices, active and passive, three moods, five simple and a number of compound tenses. Bertin, in his grammar, most of which was drawn up from Arbousset's and Lichtenstein's notes, says that beyond the present and past tenses the others were either imperfectly developed or not at all. This is not so in Sesarwa, for we have present, past, future, perfect, and past perfect, all with well-defined forms. The particles which go to express the various relations are partly suffixed and partly prefixed. In addition, there are negative forms of all tenses, formed by the addition of negative particles.

The number of individual verbal forms is very large. This is quite in keeping with many other Bushmen dialects, and is an essentially primitive characteristic in most languages. Adverbs, prepositions and conjunctions exist, though to a much smaller degree than in other languages.

On the whole, a comparison of the language of the Masarwas with other Bushman dialects as given by Muller and Planert shows a greater or lesser degree of resemblance between them, and emphasizes the fact that they all belong to one distinct family of languages, but that they have diverged so widely as to be considered independent languages rather than dialects of one language. The same remark applies to the relation of Namaqua to Sesarwa, and to most other Bushman dialects. I have derived much help from Planert's article on the "Language of the Hottentots and Bushmen," in the Proceedings of the Berlin Oriental Seminary. He has brought together many striking facts, showing the relation, near and remote, between the various Hottentot and Bushman languages. From these facts it can be inferred that Hottentot and Bushmen had a common ancestral language, of which the various Bushman types are the more primitive on the whole, with certain exceptions of which Sesarwa is one, and that Hottentot has advanced further in the stage of development. Sesarwa may be said to have nearly reached in some respects the stage of grammatical evolution that Namaqua has.

Colours of Iodine Solutions.—Recent investigations by J. Amann have shown that the violet solutions of iodine rarely contain ultramicroscopic micellæ, which, however, abound in the brown solutions. This, he holds, establishes the polymerisation of iodine.

Canadium—A New Element.—Mr. A. G. French, in the *Chemical News* (Vol. 104, p. 283) describes what is claimed to be a new element, probably of the platinum group, discovered by him in British Columbia. The metal, which the discoverer has named Canadium, occurs in metallic grains and scales along with other platinum metals in igneous dykes in the granite. It is white and lustrous, softer than platinum, ruthenium and osmium; it is easily melted by the blowpipe, dissolves in nitric acid, but is not precipitated by soluble chlorides. It is not acted on either by damp air or by sulphuretted hydrogen. From its solution in nitric acid it may be precipitated by zinc, from which it may be collected and cupelled with lead. The discoverer expects it to replace palladium for search-light mirrors, as it is more brilliant than the latter metal and easier to work: it is also expected to be adapted for use in articles of jewellery as a setting for diamonds.

THE LATENCY OF AFRICAN COAST FEVER.

By E. M. Jarvis, F.R.C.V.S.

African coast fever was imported into South Africa by way of the sea and railway into Southern Rhodesia from German East Africa in the year 1901.

Certain dealers purchased cattle in the German hinterland, and brought them down to the coastal portions. They had not been there very long before a heavy mortality ensued, when the owners thought it time to realise, so they commenced to ship the animals down the East Coast of Africa, discharging some at Beira. Eighty-two head were sent by train to Southern Rhodesia, of which number half were off-loaded at Umtali, and the other half were sent to Salisbury.

From these two centres the disease was carried by ox transport—(*a*) to Melsetter, Inyanga, and thence to Rusapi, (*b*) to Mazoe, Marendellas, Charter, Gwelo; from thence in two directions, (1) to Selukwe and Victoria, (2) to Bulawayo, Mzingwani and Gwanda. In fact, the white settled portions were mainly affected, and were more or less devastated of their cattle by the disease in 1901, 1902, and 1903.

An interval of desultory outbreaks followed, and then the disease almost disappeared until four years ago, when apparently unaccountable recrudescences took place.

The writer has noticed that these reappearances have the following characteristics:—

(1) They re-occur over the line of the original invasion.

(2) That remnants of herds from former outbreaks were invariably amongst the cattle in which the disease recrudesced.

(3) That the disease was usually first detected in the calves.

(4) That in nearly every instance the outbreak was preceded by two or three cases of indefinable fever, blood smears from which proved to be without visible evidence of, or to contain a few, protozoal bodies found in the lymphocytes, but without recognizable characters.

(5) That eventually, usually upon the fourth case, which occurred some weeks later, positive microscopical evidence of the parva with intense invasion of the erythrocytes was forthcoming.

(6) That the year was divided by periods of—

(*a*) Prevalence.

(*b*) Quiescence.

(7) That the appearances and disappearances of the Koch's bodies were likewise periodical.

(8) That the Koch's bodies were present in greater or lesser numbers, depending on the time of year.

(9) That the examination of the gland-puncture smears would first be positive, later negative, showing that the Koch's bodies tended to disappear in the same animal.

(10) That some of these aforementioned indefinable cases, when kept in a small enclosure by themselves so that they could be re-infected with nymphæ that had fallen as larvæ off their own bodies, developed in due course an attack of African coast fever (parvæ in the erythrocytes).

These features were very puzzling and irreconcilable with the known facts about coast fever. For four years I have been attempting to unravel the mystery.

I received some aid from reading Dr. Gonder's researches, but his conclusions do not explain my own observations in the field.

To proceed, an examination of the incidents of the outbreaks tabulated and aggregated into months gave me a somewhat startling correlation with the features before observed, and when the dates were still further enquired into, it was found that those outbreaks in Southern Rhodesia which fell into the month of February should have been relegated to January, and those made known in the months of September, October and November should with more propriety be placed in the months of April, May and June, when first cases did actually occur, but remained unreported till the later date.

Readjusted, we find that no actual outbreaks are to be put down to the months of February, September, October and November, and in only one year did any apparently happen in August.

Further, in the Temperature Camp system of dealing with coast fever, it has not infrequently happened that little or no advance was made in the elimination of the disease during the months of March, April, May and June, but that in the succeeding months our efforts have met with success, which achievement is, in my opinion, not solely due to the operations, for reasons which will hereafter appear.

I shall start with Koch's bodies. What are these?

I submit that they are aggregations of sexual elements whose massing together is brought about—

(1) For their protection against extinction.

(2) The evolution of sex, *i.e.*, the formation of micro- and macro- gametocytes, and, later on, ookinetes. This explains the variation in the appearances of the Koch's bodies.

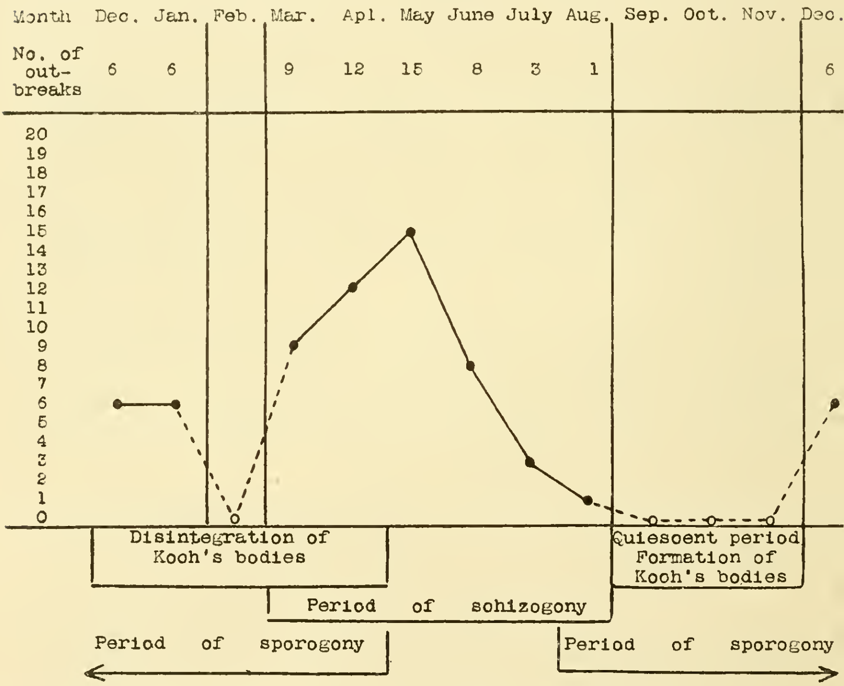
(3) In quest of a dormant period.

In December and the earlier part of the year, January to May, they commence to separate from the surrounding tissues, and the oökinetes (or oöcysts), borne within lymphocytes, are carried away to the cutaneous circulation. This disintegration is particularly active in the months of January and February, and continues into May, when it practically ceases, or rather the Koch's bodies have by this time been disrupted, and are seen again no more for a few months.

From the cutaneous circulation the attached larvæ imbibe the parasite-laden lymphocyte (containing the oökinete or oöcyst), development by sporogony continues through the nymphæ within which the sporozoites are formed, and terminates the sporogony stage.

In March, April, May, June and July the sporozoites are transmitted by the nymphæ to their bovine hosts. Prolific production of the parvæ then takes place, owing to the reinforcement which they have received during the sexual cycle; the red blood cells are intensely infested, and the microscopical examination of the blood no longer fails to yield positive evidence of their presence. We have now the schizogonal stage—if I am right in my conclusions; this is continued endo-corpuscularly.

NUMBER OF OUTBREAKS OF AFRICAN COAST FEVER AGGREGATED INTO MONTHS.



Tropozoites, schizonts, and merozoites are successively formed. As the year advances—that is, about August or thereafter—the tropozoites or schizonts gradually form themselves into Koch's bodies for the purpose of passing a quiescent period, and remain resistant to external influences up to the end of November; in December they again become active, or rather, the sexual functions are completed, and separation from the tissues begins anew. Therein is at least an explanation of the irregular results noticeable in many of the temperature camps.

The continuance of coast fever after herds have been freed of their infected units and febrile cases, and been subjected to repeated changes of clean pasture land, is made plain by reason of the active disjunction of the Koch's bodies up till the month of May, so that the larvæ are all the time able to obtain fresh elements of infection. On this theory the periods between changes of pasture have been too long, in view of the fact that efficacious dipping was out of the question.

The apparent success in the elimination of the disease about July is explainable, for indications are not wanting that where infections are conveyed in the winter months, July and August, instead of the production of merozoites—endo-globular bodies in the erythrocytes—the formation of Koch's granules takes place probably from the schizont phase; further, such animals do not then show high febrile reactions, neither do they succumb, except in rare instances. Such animals remain over to the next summer or autumn as reservoirs of infection, and in these we have a latent or endemic form.

I am not even satisfied that infected blood inoculations conducted in July will not in the same way give rise to the formation of Koch's granules, and that the extensive outbreaks in the Victoria district in 1905, 1906 and 1907 were not the result of Dr. Koch's late inoculations in 1904—an explanation as to why it was that coast fever practically disappeared and has since reappeared in increased virulence.

After the havoc in the early part of the last decade a few remnants were left, and most of these could be considered to be immune or salted, and it was from these that the Rhodesian stock-owners established their herds until fortune began to smile again, and they were able to make outside additions.

Now it is pretty conclusively proved that these remnants do not harbour the micro-parasite, neither can they, for some years at any rate, be reinfected; on the other hand, the progeny of salted parents are not all resistant, and can contract coast fever—in fact, one-third such calves succumbed to it.

The country was practically left without bulls, as they were especially susceptible, so in a number of instances no calves were forthcoming to keep infection alive, and the disease disappeared. In other instances young stock were born before the infected ticks had had time to die out, and coast fever was kept going, but unnoticed, owing—(1) to the farmer setting no store to the death of a calf or two, and not deeming the cause of death worthy of investigation; (2) the mortality was low, possibly not one in three; (3) the loss was not continuous, but seasonal, occurring mostly in the wet season, when it could be easily conjectured that the calf was smothered in mud (nearly all cattle are kept in open kraals in this country); so it simmered on; then four years ago new susceptible cattle were introduced into the herds, and the disease is assuming graver proportions, because more bovine hosts have been inserted.

My observations have led me to different conclusions to those generally expressed by other authorities, but a close study of the researches of others in the light of my deductions does not throw them into disorder except on minor points.

The causation of coast fever infections by the injection of Koch's granules are explanatory in two ways:—

(*a*) If they are composed of schizont elements, they would give rise to merozoites if injected in the autumn.

(*b*) If composed of female forms, parthenogenesis might arise.

It was the above experiment that at first sight detracted from my own conclusions, but not now.

My deductions have not been tested by experiments conducted within the quiet precincts of a laboratory free from outside cares and interruptions, and they lack this confirmation, but are the results of work performed under great difficulties, frequent intermissions and inadequate facilities for proper research. I therefore invite laboratory investigation.

My conclusions are more in keeping with the known developments of other protozoa, and they certainly offer an answer to the hitherto inexplicable features encountered in the outbreak of coast fever.

The results of the investigations made may have far-reaching consequences, and give rise to different methods of procedure.

It will mean—

(1) That cattle should not be allowed out of areas of latent infection.

(2) That freer movements of cattle could be allowed in clean areas.

(3) That transport movements should not be allowed in endemic areas.

(4) That compulsory dipping at three-day intervals will have to be enforced in endemic areas during the months of December to June inclusive. That this dipping will put coast fever *hors de combat*, for it will strike at the weak link in the chain of the life-history of the *Theileria parva*, and cut off their lives before they arrive at the stage of harmful maturity, *i.e.*, before the red cells can be invaded, that period when the mortality is so preponderant.

(5) Combined with dipping, the change of pasture at the proper periods will make assurance doubly sure.

(6) The farmer need not be deprived of his livestock, for by a dipping station centrally placed and the proper subdivision of his farm he can effectively protect his cattle.

(7) Cattle with the disease latent in them could be moved with safety in the months of September, October, and November, when destined to the abbatoirs for slaughter.

The summary of my conclusions is:—

That during the development of the causal parasite of coast fever a quiescent period is passed in the internal organs during the winter and extending into spring. Sporogony commences in the Koch's granules, is active in the summer, and continues into part of the autumn months. The lymphocytes (white blood cells) act as the mechanical carriers in the circulatory system, and supply the larvæ with the infective elements; the nymphæ act as vectors, transmitting them to the bovine. Schizogony proceeds in the blood of that host until about July, when the quiescent period again ensues.

Thus the development demands two periods in cattle and one in the intermediate host, the tick.

In the microscopical examination for coast fever the proper sequence in the appearance of the various forms will have to be recognised.

In the macroscopical examination and study of symptoms the respective periods will have to be separated.

Quiescent Period.—Negative autopsy, low febrile reaction, sporogonal stage infarctions, and other obstructions to the capillary system, low and irregular febrile temperatures.

Schizogonal Period.—High thermic reactions of a progressive character.

Mixed infections of the sporogonal and schizogonal stages are very frequent, and it is these, in my opinion, which have caused all the confusion and have hitherto disguised the true life-history of the *Theileria parva*.

Mars.—Prof. Arrhenius, in *Publications de la Société de Chimie Physique*, compares the condition of the planet Mars to that of certain desert parts of Persia, except that he considers the Martian temperature to be about 30° below zero. He thinks that the "lakes" on Mars resemble the *khévirs* of Persia, those lakes which possess so high a degree of salinity as to render their waters semi-solid. MM. Antoniadi and Bosler, on November 14, observed the whole of the planet to be of a decided citron tint, including even the polar snow cap. On December 6, M. Antoniadi records in *Astronomische Nachrichten*, he observed a large and peculiar brown spot, about 370 miles in length, and of a totally different colour to any other part of the planet, in a western part of the Mare Erythræum. A fainter spot of apparently similar character has been seen during former years.

Transmutation of Metals.—It is not surprising that, concurrently with the spread of the latest ideas on elemental change, there should be instances of reversion to the utilitarian phases of alchemistic thought. A patent has recently been granted for "a new process of treating iron to obtain gold and silver by transmutation."

SOME OBSERVATIONS ON ATMOSPHERIC ELECTRICITY TAKEN IN SOUTH AFRICA.

By Prof. William Arthur Douglas Rudge, M.A.

The author has published some observations on atmospheric electricity, taken in 1910 at the Victoria Falls; and, as it was found that the value of the potential gradient appears to vary very considerably at different places in South Africa, he thinks it may be of some interest to give here the results of some further observations, taken over a rather extensive area.

At the Victoria Falls, as is almost always the case in the neighbourhood of a waterfall, the potential gradient reaches a very high value, so high, in fact, that insulated wires stretched across the gorge become so strongly electrified that sparks may easily be obtained from them. The electrification is negative, and reaches the value of probably over 25,000 volts per metre close to the fall. The normal condition of the air, under a clear sky, gives rise to a positive potential gradient between a point in the air and the surface of the earth, the value of which varies very considerably with the nature of the country, the altitude, and the time of day when the observation is taken, and, of course, with the presence of what may be called, for want of a better term, "thunder" clouds.

A thoroughly satisfactory theory as to the origin of the enormous charges present in the atmosphere is wanting. The older theories postulated that the condensation of water vapour was accompanied by the production of an electric charge upon the drops formed, and so also was the evaporation of water from the surface of the earth supposed to be accompanied by electrification of the earth itself—ideas probably incorrect. In the present state of our knowledge, it is best to leave the origin an open question.

The natural charge present in the atmosphere is very large, it having been estimated that a difference of potential of the order of 150,000 (!) volts exists between the confines of the atmosphere and the surface of the earth. If we take the height of the homogenous atmosphere as 10,000 metres, this gives an average potential of 15 volts per metre, but the value near the surface of the earth is much greater than this, so that the potential "gradient" diminishes as we go upwards. This normal value may be largely exceeded—10 to 100 times as great—and may also be reduced. The charge is usually positive, but occasionally negative. The experimental facts of atmospheric electricity may be explained by supposing that the earth has always a negative charge, which gives rise to an electric field surrounding the earth; this would cause positive ions to move towards it, thus producing the potential gradient between the earth and the surrounding air.

The observations were taken by means of an "Exner" pattern electroscope furnished with a wire, to which was attached a small plate covered with a radium preparation. The instrument was mounted upon a telescopic stand, so that the height of the plate above the ground could be varied. From a plate coated with a radioactive preparation a stream of ions will shoot off, and, if the plate is in an electric field, it will rapidly take the same potential as that portion of the field in which it is resting. The same thing happens to a wire to which a piece of smouldering tinder is attached, and also to an insulated vessel furnished with a long tube from which water may be dropped, as used originally by Lord Kelvin. The radium preparation, whilst open to certain objections, is undoubtedly the most convenient, especially when taking observations whilst moving from place to place.

The method of observation consisted in setting up the electroscope and adjusting the height of the plate above the ground until a readable deflection of the gold leaf was seen. The leaf was observed from a short distance by an opera-glass, so that the presence of the observer should not interfere. In some cases the gold leaf diverged so far that it touched the earthing plate, so that in these, the potential could not be found directly, but had to be inferred from the rate at which the charge rose to the maximum. The sensitiveness of the instrument would be varied from 1 division for 10 volts to 1 division for 26 volts, the whole range running up to about 600 volts. The gold leaf rapidly took up its position, and, if no wind was blowing, remained steady, so that observations were easily taken.

In comparing observations at different places, it is essential to make use of those taken at corresponding periods of the day. This was not always possible, but by "smoothing" curves and taking averages, it was possible to get a fairly good result for 10 a.m., the time usually taken for comparison purposes.

In May, 1910, an extended series of observations was taken at the time of passage of Halley's Comet near to the earth. During that time the potential gradient varied from about 200 to 40 volts per metre. The value from day to day was fairly constant with maxima occurring at about 8 a.m. and 7 p.m.

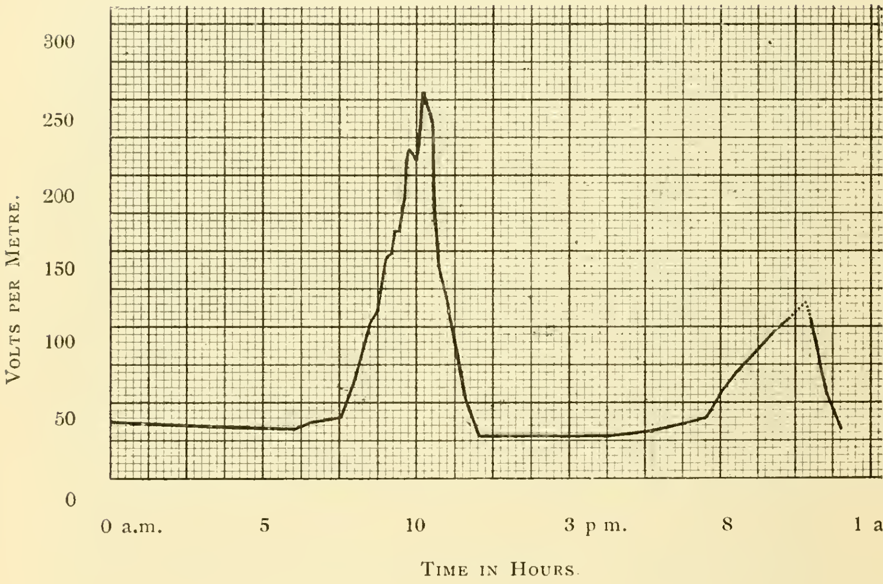
The table and curve show the variations during a day.

TABLE SHOWING ONE DAY'S OBSERVATION AT BLOEMFONTEIN.
4570 ft. ABOVE SEA-LEVEL.

Time.	Potential Gradient.	Time.	Potential Gradient.	Time.	Potential Gradient.
0 0 a.m.	38	9.20	163	10.45	130
6. 0	32	9.25	163	11. 0	114
6.30	36	9.35	185	11. 1	92
7.30	40	9.40	208	11. 2	86
8. 0	66	9.45	217	11. 8	70
8.20	89	9.47	210	11.10	66
8.30	103	10. 0	210	11.15	60
8.40	109	10.10	255	11.20	56
8.56	136	10.20	235	11.22	52
9. 0	145	10.30	163	11.25	52
9.10	148	10.35	140	11.35	52

Time	Potential Gradient.	Time.	Potential Gradient.	Time.	Potential Gradient.
11.45	29	6.30	35	11.10	77
11.57	29	7.30	40	11.30	57
12. 0 noon	33	8. 0	56	11.40	40
12. 5 p m.	28	9. 0	70	11.45	39
12.50	28	9.50	78	11.55	32
3.50	28	10. 0	101	12. 0	32
4.10	28	10.20	106		
5.40	31	11. 0	106		

Fig. 1.

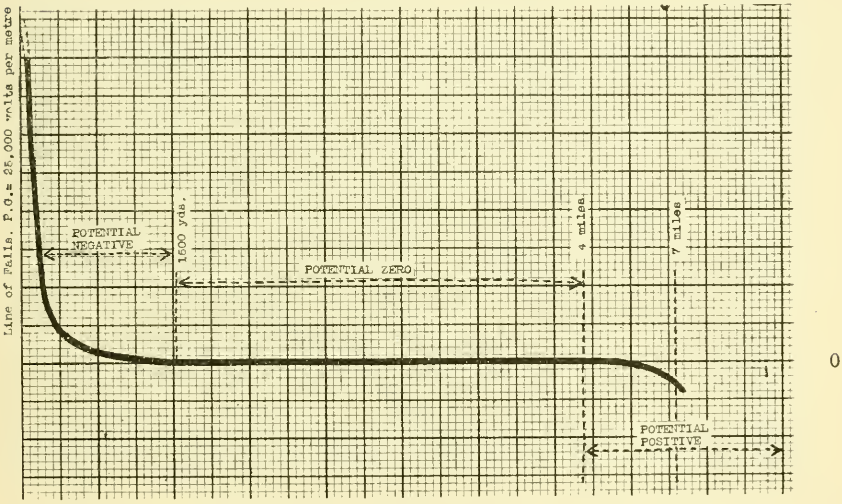


In July, 1910, observations were made at Victoria Falls, Kesi, Wankie, Pasipas, Bulawayo, Westacre, Matoppos, Mahalapye, Artesia, Lobatsi, Mafeking, Vryburg, Taungs, Potchefstroom, Johannesburg. The complete set of observations at the Falls has been already referred to, but it may here be noted that at a distance of two miles from the Falls their influence was almost negligible, while further away the ordinary electrical state existed. Within a mile of the Falls, the potential gradient was at times of the order of over 600 volts per metre, and *negative*, while at Livingstone it did not exceed 60 volts, and was *positive*. On the river above the Falls, the value was zero for some distance; and at seven and a half miles, it was about 100 volts and positive.

The curve shows how the potential gradient varied as one receded up the river from the fall. It cannot very well be drawn to scale, as the highest point of the curve above the zero line would have to be 250 times the height of the lowest point below the line. The Zambesi river above the Falls is about 3,000 feet above sea-level.

Between Bulawayo and Potchefstroom, the general level of the country does not vary much, and the potential gradient was also uniform and of the order of 150 to 160 volts per metre. At Rhodes's grave and at Johannesburg the values were about 40. In January of this year observations were taken during a journey to Cape Town, with the general result that a steady increase of the potential gradient was observed as the elevation diminished.

Fig. 2.



Over the veld and Karoo, the value was about 150; at Worcester it rose to 170, and this at a later hour, when the potential is usually lower.

Cape Town Observations.—Observations were taken at various points on the coast between the Docks and Camps Bay. The general value of the potential gradient was high, going up to over 500 volts per metre in some instances, but very great fluctuations occurred, owing to a combination of the effects of sun, cloud and wind.

The following are some typical cases:—

January 8th: Bright sun, clear air, no cloud; at 20 feet above sea-level the potential gradient was 550.

January 9th: Misty, clouds below top of Lion Rock, but Rock visible above the clouds; potential gradient was 225 volts per metre. As the cloud rose, the top of the Rock became covered, and the potential fell to about 100. On the cloud rising further or, rather, moving away, the potential fell still further

January 12th: Wind S.W., cloud above but not on Table Mountain; gradient generally less than 100, but occasionally higher.

January 13th: Wind S., plenty of clouds, but high, so that the sun was seldom obscured. Potential gradient at sea-level 500 volts per metre.

January 15th: Cloud pouring over Table Mountain, S.E. wind. Observations at Green Point: Potential varied from 0 to 100 volts per metre in the course of an hour. Generally the S.E wind was accompanied by low potential gradients.

January 10th: Cloud over top of Lion Rock; potential gradient 90. On sun breaking through cloud gradient rose to 130.

From the observations already recorded, it seemed likely that the potential gradient would vary with the altitude, and a number of observations were taken at different heights above sea-level. A very marked difference in the gradient was seen. For example, the electroscope stand was placed in a pool close to the water ,when the potential gradient was found to be over 400. The height of the collecting plate was 150 cm. above the water. On placing the electroscope on a rock at a height of about 6 metres above the sea, the gradient was reduced to about 300. Repeated observations confirmed this very abnormal reduction, and it may be due to some difference in the conducting power of the rocks and sea-water. The electroscope was then carried up the mountains to a height of about 1,000 feet, and observations taken at various points during the descent, the height being taken as inversely proportional to the pressure indicated by an aneroid barometer. At the highest point the potential gradient was 56, at sea-level it was 260. Many observations showed that the higher the position the smaller the potential gradient, but a more systematic and extended series of observations is necessary to prove this, and of course the observations at the different points should be conducted simultaneously, as the potential gradient varied from day to day and from hour to hour.

In April of this year a set of observations was taken between Van Reenen's Pass and Durban, with the object of confirming the inference made at Cape Town, *viz.*, that the potential gradient is inversely proportional to the altitude.

Van Reenen is at an altitude of about 6,000 feet. There is a fairly steady fall down to Ladysmith at 3,300 feet; from Ladysmith to Durban there are considerable fluctuations as far as Thornville, then a steady fall down to Durban. The observations taken were, however, very incomplete, as the time available was only that due to the stoppage of the train. But the general result was apparently the same; the potential gradient increased as the altitude diminished.

During the first of the three days at Van Reenen, the sky was clear up to 3.30. The potential gradient was low, not going above 60 between 7 a.m. and 4 p.m. At 4.30 a violent thunderstorm broke over the Pass, and after this subsided, a very strong degree of positive electrification remained in the air. The potential gradient was now over 500 volts per metre, this persisting up till 10.30 p.m. On the next day, the charge in the air was practically nil until 10 a.m., when it became just measurable.

Observations were taken not far from the railway, and it appeared that the passing of a train had a very considerable disturbing effect, which was traced to the steam emitted from the funnel or from the safety-valve, or even from that escaping from the cylinder when blowing off. At 200 yards' distance the passing of an engine under steam would cause the gold leaf to be deflected up to the maximum, that is, the potential gradient would rise to over 550 volts per metre.

The charge was always positive, and persisted in the air for a long time after the cloud had suffered visible condensation, in some instances for more than fifteen minutes. The charge increased during the day, and on occasions went up to 350 volts. The wind was rather strong, this accounting to some extent for the variations.

At Ladysmith, 6.30 to 9 a.m.: Potential varied from 40 to 100 volts. At various stations between Ladysmith and Pietermaritzburg the potential varied only slightly, but as the time of day varied no very satisfactory conclusions could be drawn. At Durban the potential gradient was always greater than at any point after Van Reenen. The weather was warm and hazy, and the gradient never went beyond 160 volts per metre, a value very much less than had been found at Cape Town. On the return journey, a good set of observations was taken between Ladysmith and Van Reenen; the potential gradient falling as the altitude increased.

These observations cannot claim any very high degree of accuracy, but they are comparative, and appear to show that the potential gradient does diminish with the altitude, and that over a large stretch of country. At approximately the same height above sea-level the potential gradient has generally the same value. The gradient could also be determined if observations were taken of the conducting power of the air and of the magnitude of the earth-air current.

It would be equal to the quotient of the current of the conductivity. Now the conductivity of the air increases with the altitude owing to the diminution in pressure, and perhaps also owing to the more potent effect of the ultra-violet light of the sun causing more complete ionisation, from which it may be inferred that the potential gradient will fall.

The nature of the normal charge observed was always positive, save in the case of the Victoria Falls, where it was strongly negative. It is well known that when water is broken up into a fine spray by mechanical means, the water becomes positively electrified, whilst the air in the neighbourhood becomes negatively charged. The condensation of steam to water is evidently accompanied by the production of a positive charge in the air; hence it may be inferred that the drops of water falling to the earth should carry with them a positive charge. This requires further investigation.

THE MEAN DISTANCES OF THE PLANETS.

By R. T. A. Innes.

The mean distance of a planet is equal to the semi-axis major of its orbit considered as an ellipse. This mean distance only coincides with its *average distance* if the eccentric anomaly is taken as the independent variable. If time is taken as the independent variable the average distance is

$$a\left(1 + \frac{e^2}{2}\right),$$

in which a is the semi-axis major and e the eccentricity.

This equation by itself shows that as e diminishes, the total amount of radiation received from the Sun increases, because the average distance is getting less, and this is the case of the Earth in the present age, as the eccentricity of its orbit is decreasing slowly. If, with the present rate of decrease of the eccentricity, the Earth is neither getting hotter nor colder, or, in other words, that its radiation is exactly balanced by its absorption, as meteorologists confidently assert, then the moment the eccentricity ceases to decrease, and more so when it begins to increase, the Earth's temperature will fall until a balance is again struck. If this reasoning is correct, it follows that an Ice Age would not be due so much to the large eccentricity of the Earth's orbit as to the fact that the eccentricity is increasing.*.

If the true anomaly is taken as the independent variable, the average distance is

$$a(1-e^2).$$

The researches of Laplace, Lagrange, Poisson and other astronomer-mathematicians have proved that the mean distances of the planets from the Sun are invariable, so far as concerns their mutual attractions, but it is possible that secondary causes such as increases of mass due to the fall of meteorites, tidal effects, retardation due to matter in space, etc., may cause the mean distances to change. The astronomer can only assert that such changes, if they do exist, are too minute to have yet been revealed in the cases of the planets; the decrease of the distance of Encke's Comet which is very irregular in its amount shows

* Perhaps the argument needs enlarging. During the period of perihelion the Earth receives more heat from the Sun than it does at aphelion in any given number of days, but as a whole its rise in temperature is very slight, because as the temperature of a body rises its radiating power increases (as the 4th power of the absolute temperature in the case of a black body). If we accept that over a series of years during which the Earth's average distance is decreasing from

$$a\left(1+\frac{e^2}{2}\right) \text{ to } a\left(1+\frac{e^2}{2} - e\Delta e\right)$$

it just maintains a balance between its rates of absorption and radiation, it would follow that when Δe (change of the eccentricity) alters its sign, the equilibrium will be upset and the Earth as a whole will change its temperature, and as long as e is increasing the Earth will grow colder. In other words, the combined effect of the 4th power law and the diminution of the eccentricity of the Earth's orbit is to maintain the Earth at its present mean temperature.

that such secondary causes are at work. But at present the astronomer is fully justified in asserting that the mean distances of the planets (semi-axis-major of the elliptical orbit) is invariable. In a paper published in this journal in 1911, January, the writer gave a table of the mean distances of the eight major planets, but he remarked that the values given for the planets Uranus and Neptune were not the true mean distances as they had been derived from mean motions which included effects due to Newcomb's method of dealing with the great inequality in the motions of those two planets. This paper will give revised figures and will include the mean distances of the two small planets Eros and Ceres.

The writer is of the opinion of the American astronomers, Hill and Newcomb, and of the French astronomer Tisserand (who adopts Laplace's procedure) that the mean distance of a planet should be so chosen that it is only subject to periodical variations. Unfortunately it is very difficult to measure the distance of a planet from the Sun directly, and astronomers always use an indirect method founded upon Kepler's law connecting the distances and periods. If there were but one planet and the Sun, the equation connecting the two quantities is

$$a^3n^2 = k^2(1 + m)$$

in which

a = semi-axis major (mean distance).
n = mean motion in a fixed unit of time.
k = attractive force of the Sun in some convenient unit.
m = mass of the planet in terms of the mass of the Sun.

If another planet is considered (let us suppose it to be the Earth), and the mutual attraction of the two planets is left on one side for the moment, we should have the similar equation

$$a_{,}{}^3\, n_{,}{}^2 = k^2(1 + m_{,}).$$

If we now choose that the mean distance of the Earth be the unit of distance, the distances of other planets can be determined when their mean motions and masses are known. But the above simple equations do not hold when the mutual attractions of the planets are considered. The observed mean motion of a planet is made up of one part (by far the greater) due to the action of the Sun and a smaller part due to the action of the other planets of the system. The same remarks apply to a planet's mean distance. The full elucidation of this problem depends on the disposal of the constants introduced by the integration of the differential equations of motion. The net result is that if the action of the planets increases the motion of any planet by σn (σ being a very small factor in the Solar System) the effect on the mean distance computed by means of the above equations is $\frac{1}{6}\sigma$. If the constants added to the mean distance itself are neglected, this correction would be $\frac{2}{3}\sigma$, which is four times too great. Reference to Tisserand's *Mécanique Celeste*, t. iv, p. 18, should be made by those wishing to find proofs of these statements. The formulæ which are applicable for the eight major planets are given on pages 107 and 108 of this journal for 1911, January. In the cases of the minor planets Eros and Ceres, such simple formulæ cannot be used as an algebraical expansion of the perturbative function is too slowly convergent for practical use,—in fact, for the case Eros disturbed by Mars, the algebraical expansion is divergent. For these two planets we must have recourse to other means, and fortunately Mr. C. J. Merfield has computed the secular perturbations of both of these planets by a celebrated method devised by Gauss.

In the case of the planet Eros, it happens that the correction to the elliptic semi-axis-major is nearly negligible. Using the data provided by Mr. Merfield in Nos. 4178-9 of the *Astronomische Nachrichten* for 1907, May, we find

Action of	δLa for Eros (in units of the 8th decimal).
Mercury	+ 2
Venus	+ 42
Earth	+ 74
Mars	+ 3
Jupiter	— 170
Saturn	— 7
Uranus and Neptune	— 0
Total	— 56

Hence $La = 0.1638127 - .0000006 = 0.1638121$.

In the case of the planet Ceres, using the values of $\sigma \iota = [\frac{dL}{dt}]_{00}$ given by Mr. Merfield in the Monthly Notices of the Royal Astronomical Society LXVII, p. 560, we have

Action of	δLa for Ceres (Units of 8th decimal).
Mercury	+ 2
Venus	+ 36
Earth	+ 50
Mars	+ 6
Jupiter	— 1441
Saturn	— 54
Uranus	— 1
Neptune	— 0
	— 1403

The mean distance of Ceres is therefore as follows:—

	La	a
Elliptic value using observed mean motion ..	0.4420738	2.767412
True semi-axis-major from which the planet only departs by periodic perturbations	0.4420598	2.767323

In a paper published in the Monthly Notices of the Royal Astronomical Society (1910, December, page 127), the writer gave the results of a rough calculation for this case, viz.,

$$\delta La = -0.0000154$$
$$\text{or} \quad a = -0.000100$$

but unfortunately the last number was incorrectly given as —0.000010, which is ten times too small.

Turning now to the planets Uranus and Neptune. In vol. XXVIII. of the Annales of the Observatory of Paris (Mémoires) which has just appeared, Monsieur A. Gaillot brings to a conclusion his researches on the motions of the planets Uranus and Neptune accompanied by tables for the preparation of ephemerides, and in fact his tables are used in the Connaissance des Temps for 1913. Monsieur Gaillot's work is closely modelled on the lines of Le Verrier's theories. We have thus two modern theories with tables for these planets:—(a) Gaillot's based on the method of Lagrange's variation of elements; (b) Newcomb's based on the perturbations of co-ordinates in which Hansen's method appears. Comparisons of the ephemerides for 1913 show quite small differences, but one cannot help remarking on the shortness of the calculations actually made by Newcomb and the brevity of his tables. It is true that Newcomb did not publish his calculations in full, but the criticism seems just; Newcomb avoids some considerable work by not developing the great inequality in the longtitudes of Uranus and Neptune, one consequence is that his elements of the two planets' orbits are not the mean elements. Monsieur Gaillot's work puts us in possession of these.

The great inequality just mentioned is caused by the near commensurability of the mean motions of the two planets, the mean motion of Uranus being nearly twice that of Neptune. This inequality takes 4,230 years to go its course; it can displace Uranus from its mean place in orbit by over 3150″ and Neptune by 2150″.

Tables showing the elements according to these two astronomers are not without interest.

Uranus.

	Newcomb.			Gaillot.		
Epoch.	1900, Jan. 0.0 Greenwich Time.			1900, Jan. 0.0 Paris Time.		
Mean Longitude	243°	21′	44.66″	244°	12′	32.71″
Perihelion ...	169	2	55.6+2890.7″ T	171	32	55.1+3192 82″ T
Node	73	29	24.9−3189.0 T	73	28	36.4—3233.3 T
Inclination ...	0	46	21.597+2.203 T	0	46	20.87+2.109 T
Mean Movement	15426.0928″			15424.83806″		
Eccentricity ...	9703.59−5.427″ T			9559.22−5.499″ T		
Mass of Neptune	1/19314			1/19094		

Neptune.

Epoch.	1900, Jan. 0.0 Greenwich Time.			1900, Jan. 0.0 Paris Time.		
Mean Longitude	85°	1′	30.63″	84°	27′	50.02″
Perihelion ...	43	45	20.2+80.5 T	46	43	38.2+103.2″ T
Node	130	40	44.0—1060.3 T	130	40	52.8—1068.5 T
Inclination ...	1	46	45.32—33.495 T	1	46	45.27—34.324 T
Mean Movement	7864.8042″			7865.6413″		
Eccentricity ...	1760.142+1.061 T			1855.77+1.306 T		

T = 100 years.

The deviation of Newcomb's elements from the mean elements is marked, thus the perihelion of Neptune's actual orbit is nearly 3° from its mean position, and the eccentricities of both planets are considerably greater than the mean eccentricities.

Newcomb's values for the semi-axes majores have been deduced by him from the observed mean motions and then corrected for the constants due to planetary action:—they are

	Log. a.	
Uranus	1.2830871	Including effects of the Great Inequality.
Neptune	1.4781432	

Gaillot gives

Uranus	1.2837113
Neptune	1.4787045

and states that these values have been deduced from the observed mean sidereal motions after subtracting the parts proportional to the time in the mean longitude due to the actions of Jupiter, Saturn and Neptune. Gaillot's tables have therefore to include, in the pertubations of the radius vector, the constants above referred to so that the semi-axis-major as defined in his tables does not represent a true mean-semi-axis major.

From Monsieur Gaillot's own data, we derive

Elliptic Value + $\frac{1}{4}$ of Constant Terms = True semi-axis major.

Uranus	$1.2829239 + \frac{1}{4}(0.0007874) = 1.2831207$
Neptune	$1.4779160 + \frac{1}{4}(0.0007885) = 1.4781131$

The calculation for Uranus is as follows:

$$
\begin{aligned}
L\sqrt{1+m} &= 0.0000095\\
L\ k &= 6.1125968\\
&\overline{\ \ 6.1126063\ \ }\\
L\ n &= 4.1882205\\
&\overline{\ \ 1.9243858 \times \tfrac{2}{3} = 1.2829239}
\end{aligned}
$$

The constant terms are 1.2837113 — 1.2829239 = 0.0007874.

One cannot but remark that the uncorrected elliptic values are nearer the true mean distances than those given by Monsieur Gaillot. If, therefore, it is not intended to apply the correction to both the mean motions and the distances, it is better not to apply any correction.

The definition of mean distance given above does not depend on the assumption that the planets travel in ellipses but is derived from the differential equations of motion so that it reads, "The mean distance of a planet is that distance from which it only deviates by strictly periodical quantities," when the eccentric anomaly is the independent variable.

But it is not likely that this journal would be referred to by the student who wants to find the mean distances of the planets,—he would naturally refer to one of the two authorities, the American Ephemeris for 1913 or the Connaissance des

Temps for 1913,—these being the latest years published; if so he will find the following figures:—

Planet	American Ephemeris	Connaissance des Temps
Mercury	0.387099	0.387098
Venus	0.723331	0.723330
Earth	1.000000	1.000001
Mars	1.523688	1.523678
Jupiter	5.202803	5.202555
Saturn	9.538843	9.554751
Uranus	19.190978	19.217827
Neptune	30.070672	30.108980

It is the writer's opinion that the first set is the correct set, but the very fact that there are differences shows that it is necessary for astronomers to define more fully what they mean when they refer to the mean distance of a planet.

TRANSACTIONS OF SOCIETIES.

Geological Society of South Africa.—Monday, November 20th: Dr. E. T. Mellor, President, in the chair.—"The intrusive rocks of the Witwatersrand": D. P. **McDonald**. The author began by describing typical examples of the intrusive rocks met with in the mines. Two varieties of acid intrusive rocks may readily be distinguished, namely a microgranite and a reddish-coloured granophyre. Rocks of intermediate composition are apparently not very numerous: except for the sheets of syenite or of tonalite, a pyroxene-andesite is the only rock examined which can with certainty be placed in this group. The basic intrusive rocks belong to the two classes of dolerite and olivine-dolerite. The greatly metamorphosed basic dykes were next examined in detail, and the conclusion expressed that the course of alteration had been considerably affected by internal movement. With regard to the relative ages of the intrusions, obviously the metamorphosed dykes were the oldest, and the micrognanite intrusions must also be of early date. The second group of intrusions includes the red granophyres, and the third the rocks of most basic composition.—"The normal section of the Lower Witwatersrand System on the Central Rand, and its connection with West Rand Sections": Dr. E. T. **Mellor**. The author disagreed with the accepted view that the wide differences between sections on the Central and West Rand are due to original differences of deposition, and that the Lower Witwatersrand System showed a great increase in thickness towards the west. The differences referred to were ascribed mainly to a system of strike-faults. The Elsburg beds, though unconformable to the Lower Witwatersrand beds, are not necessarily so to the upper part of the system, and there was not sufficient evidence for the removal of the Elsburg beds to another system. The beds of the Lower Witwatersrand System appear to have been deposited under deltaic conditions.

NEW BOOKS.

Smith, H. Sutton.—"*Yakusu*": *the very heart of Africa: being some account of the Protestant Mission at Stanley Falls, Upper Congo.* London: Marshall Bros. [1911]. pp. xviii., 288. 9 in × 5½ in. Maps, illus. 6s. nett.
Tucker. Alfred R.—*Eighteen years in Uganda and East Africa.* New ed. London: E. Arnold, 1911. pp. xvi, 362. 8 in. × 5 in. Map, illus. 7s. 6d. nett.
Blackburn, Douglas, and **W. Waithman Caddel.**—*Secret Service in South Africa.* London: Cassell & Co., 1911. pp. xi., 580. 24 oz. 10s.
Mills, Dora S. Y—*What we do in Nyasaland.* London: Office of the Universities' Mission to Central Africa, 1911. pp. ii., 266. Post 8vo. 17 oz. 2s.
Bleek, W. H. I., and **L. C. Lloyd.**—*Specimens of Bushman Folklore.* London: George Allan & Co., 1911. pp. xl, 468. 8vo. 38 oz. 21s.
Gouldsbury, C., and **H. Skeane.**—*The Great Plateau of Northern Rhodesia.* London: Edward Arnold, 1911. 8vo. pp. xxii, 360. Maps and illus., 40 oz. 10s.
Johnston, Sir H. H.—*Pioneers in West Africa.* London: Blackie and Son., 1911. 8vo. pp. xiv, 336. 32 oz. 6s.
Weeks, Rev. J. H.—*Congo Life and Folklore.* London: Religious Tract Society, 1911. 8vo. pp. xxii, 468. 26 oz., 5s.
Roscoe, Rev. J.—*The Baganda: An Account of their Native Customs and Beliefs.* London: Macmillan and Co., 1911. 8vo. Illus. pp. xix, 547. 15s.
Fitzsimons, F. W.—*The Monkeyfolk of South Africa.* London: Longmans, Green and Co., 1911. 8vo. pp. xv, 167. 26 oz. 5s.
Evans, M. S.—*Black and White in South-East Africa.* London: Longmans, Green and Co., 1911. 9 in. × 6 in. pp. xviii, 342. 6s.

ADDRESSES WANTED.

The Assistant General Secretary (P.O. Box 1497, Cape Town) would be glad to receive the correct addresses of the following members, whose last-known addresses are given below:—

Aspland, C. Hatton, Witwatersrand Deep, Ltd., P.O. Box 5, Knight's, Transvaal.
Barton, Ernest Mortlock, Director of Works Department, Simonstown, Cape.
Bay, Dr. B., P.O. Box 5513, Johannesburg.
Bell, W. Reid, M.I.C.E., F.R. Met. Soc., M.I.E.S., P.O, Box 2263, Johannesburg.
Boulton, H. C., c/o Messrs. Pauling & Co., Ltd., Broken Hill, Rhodesia.
Brown, W. B., c/o Engineer-in-Chief, S.A. Railways, Cape Town.
Champion, Ivor Edward, P.O. Roberts Heights, Pretoria.
Crockett, John, 10, Transvaal Bank Buildings, Johannesburg.
Dickie, Andrew, 475, Currie Road, Durban, Natal.
Jorissen, Dr. E., Louth's Buildings, Salisbury, Rhodesia.
Leech, Dr. J. R., 4th Avenue, Melville, Johannesburg.
Macfarlane, Donald, M.I.C.E., H.M. Naval Dockyard, Simonstown, Cape.
Mirrilees, W. J., 9, London Chambers, Durban.
Nichol, Thomas Thompson, P.O. Box 34, Springs, Transvaal.
Nicholas, W. H., Durban High School, Durban, Natal.
Nicholson, J. Greg, Leliefontein, Government School, P.O. Carolina, Transvaal.
Petersen, H. T., P.O. Box 5, Cleveland, Transvaal.
Preston, James, 89, Arnold Road, Observatory, near Cape Town.
Southwell, Miss Jessie, 270, Visagie Street, Pretoria.
Van Oordt, J. F., Harrismith, O.F.S.

THE ELECTRO-MOTIVE SERIES OF THE METALS AS AN AID TO THE TEACHING OF INORGANIC CHEMISTRY; WITH SPECIAL REFERENCE TO THE ACTION OF ACIDS ON METALS.

By Prof. Robert Beckett Denison, D.Sc., Ph.D.

Perhaps the greatest difficulty in the teaching of Inorganic Chemistry to young students is that they persist in regarding the subject as a collection of facts which have to be learned by heart. When they have grasped the meaning of the Periodic Classification there does come, it is true, a little law and order among the facts, but there are many phenomena with regard to which the Periodic Classification gives but little help. Particularly is this the case when it is a question of salt formation from a metal and an acid, and, in short, wherever the fundamental nature of the process is the formation or disappearance of ions. Even with a knowledge of the Periodic Classification the student generally finds less difficulty with Organic than with Inorganic Chemistry after he has once overcome the initial apparent difficulties of the former. This is because, as he puts the matter, you know what is going to happen to an organic substance if you know its constitution, whereas in Inorganic Chemistry there is no such guide. Most inorganic substances are electrolytes, and so in aqueous solution are largely in the ionic condition. It is, perhaps, this common behaviour which causes the constitution of an inorganic compound to be of so little importance. What we require to know is the relative tendency of the different substances to go into the ionic condition. This knowledge is given us, not by the Periodic Classification, but by the Electro-motive Series.

The Electro-motive Series is generally regarded as a physical rather than a chemical classification. To the student of Physics it means that if two metals are separated by a suitable electrolyte and joined outside by a wire, an electric current will flow in a certain direction depending on the relative position of the metals in the series.

To a student of Chemistry, however, it should mean much more than this. Writing down the commoner metals as they occur in the Electro-motive Series, *viz.*,

K, Na, Ca, Mg, Al, Zn, Fe, Sn, Pb, Cu, Hg, Ag, Pt, Au,
(H)

we see at once that the most easily oxidised metals are at the head of the series. This can be demonstrated very strikingly to a class by exhibiting samples of Potassium, Sodium, Calcium, Magnesium and Aluminium. The older the specimens are, the more evident is it that the above order represents the tendency towards oxidation. If now, we take any basic oxide and treat it with an acid, we get, as every student knows, water plus a salt. Personally, I always mention the water first, because it is really the formation of water which causes the reaction to take place.

Hence for two metals, M_1 and M_2, which are to be converted into salts by oxidation and subsequent treatment with acid, we have the equations

I. (*a*) M_1 + oxygen = M_1 oxide.
(*b*) M_1 oxide + same acid = M_1 salt + water.
II. (*a*) M_2 + oxygen = M_2 oxide.
(*b*) M_2 oxide + acid = M_2 salt + water.

In these cases the tendency to undergo reaction is practically the same in I*b* and II*b*, the formation of water being as it were the driving force in each case. Hence if the tendencies of the total reaction Metal = Salt are different in the two cases (as they actually are), the cause of the difference is to be sought in the processes represented by I*a* and II*a*, *i.e.*, in the different tendency of the two metals to undergo oxidation. Thus we see that the relative tendency of a metal to undergo oxidation is also its relative tendency to form salts. Hence the metals high up in the Electro-motive Series will never occur native on account of their salt-forming tendencies, whereas the metals at the bottom of the series will generally be found uncombined in nature owing to the difficulty with which they form salts. But a metal may be converted into a salt by another process, *viz.*, by the direct action of an acid. In this case we have (taking the metal as divalent) $M_1 + 2\,HCl = M_1\,Cl_2 + H_2$.

But a solution of HCl. consists chiefly of hydrogen and chlorine ions, $\overset{+}{H}$ and $\overset{-}{Cl}$. Similarly $M_1\,Cl_2$ in solution consists largely of $\overset{++}{M_1}$ and $\overset{-}{Cl}$ ions. We can therefore write the above equation in the form,

$$\underset{\text{Metal}}{M_1} + \underset{\text{ions}}{2\,\overset{+}{H}} + \underset{\text{ions}}{2\,\overset{--}{Cl}} = \underset{\text{ions}}{\overset{++}{M_1}} + \underset{\text{ions}}{2\,\overset{-}{Cl}} + \underset{\text{gas (unionised).}}{H_2.}$$

$$\text{or} \quad \underset{\text{Metal}}{M_1} + \underset{\text{ions}}{2\,\overset{+}{H}} = \underset{\text{ions}}{\overset{++}{M}} + \underset{\text{gas.}}{H_2.}$$

Thus the action of an acid on a metal to form a salt really consists (on the ionic theory) in the taking away of the electric charge from the hydrogen ion by the metal atom. The metal atom must thus have a greater affinity for an electric charge than the hydrogen atom, and with different metals the relative tendency of these to dissolve in acids to form salts must be the same as the relative tendency of the metals to rob the H ions of their charges. The electric charge on an ion, in fact, behaves as if it were a chemical element, and the different metals have different affinities for this ionic charge, just as they have different affinities for oxygen, chlorine, etc. The Electro-motive Series expresses the relative value of this affinity, which, moreover, can be expressed definitely in numbers, which are obtained as the results of physical measurements. We are thus able to give to each atom a number expressing its tendency to stick to its electric charge when in the ionic form, or its tendency to take up an electric charge if in the atomic form. Since the conversion of metal into salt consists in the change metal to ion, we have then that the position of a metal in the Electro-motive Series really gives us its relative tendency to oxidation, to salt formation, and to displace hydrogen from acids.

According to this view, the liberation of hydrogen from an acid by a metal is exactly the same process as the deposition of copper from a solution of copper sulphate by metallic zinc, since this reaction may be expressed by the equation,

$$\underset{\text{Metal}}{Zn} + \underset{\text{ions}}{\overset{++}{Cu}} + \underset{\text{ions}}{\overset{--}{SO_4}} = \underset{\text{ions}}{\overset{++}{Zn}} + \underset{\text{metal}}{Cu} + \underset{\text{ions.}}{\overset{--}{SO_4}}.$$

$$i.e., \quad \underset{\text{Metal}}{Zn} + \underset{\text{ions}}{\overset{++}{Cu}} = \underset{\text{metal}}{Cu} + \underset{\text{ions.}}{\overset{++}{Zn}}.$$

Such a deposition of one metal by another is governed by the relative affinity of the metal atom to go into the ionic state, *i.e.*, by its position in the Electro-motive Series. Now hydrogen behaves in all electrolytic processes as a metal, and so has a definite position in the Electro-motive Series. Hence the metals above it should displace hydrogen from a solution of its ions, *i.e.*, from an acid solution. On the other hand, no hydrogen will, as a rule, be evolved by the action of acids on the metals which are below hydrogen. This important method of viewing the action of acids on metals is capable of extension in many ways. Applying the law of mass action to the reaction

$$\text{Metal} + \underset{i.e.,\text{ an acid.}}{\text{Hydrogen ions}} = \underset{i.e.,\text{ a salt.}}{\text{Metal ions}} + \text{Hydrogen gas},$$

we see that the tendency of the reaction to proceed from left to right depends not only on the affinity of the metal for an electric charge (which affinity finds its expression in the mass action constant), but also on the concentration of the hydrogen ions, *i.e.*, on what we often refer to as the "strength" of the acid and also on its concentration. Thus it is that some metals will cause the evolution of hydrogen from weak acids like acetic and which contain relatively few hydrogen ions, whereas other metals lower down in the Electro-motive Series are unaffected. Further, the affinity of potassium, sodium and calcium for an electric charge or their ionisation tendency is so great that they will displace hydrogen from solutions containing even very small amounts of hydrogen ions, *e.g.*, from pure water. It is, however, clear that only the metals at the top of the series will possess this capability.

Further, we know that hot concentrated sulphuric acid will attack copper and silver, forming sulphates and liberating SO_2.

A student occasionally asks if the liberation of SO_2 is due to the reduction of the H_2SO_4 by nascent hydrogen or by copper. According to its position in the Electro-motive Series copper cannot displace hydrogen from sulphuric acid. It can only go into the ionic form, *i.e.*, as copper sulphate, by being oxidised to CuO. This, of course, then reacts with the acids to form $CuSO_4$. Owing to the fact that silver is below copper, silver will be attracted by hot sulphuric acid even less readily than copper, and gold and platinum have so little tendency towards oxidation that even hot concentrated H_2SO_4 or HNO_3 has no action.

Another advantage of this point of view is that it gives us a perfectly plausible conception of what is generally termed "nascent hydrogen," a term which students accept, but do not as a rule attempt to understand.

Sometimes the text-book suggests that the activity of nascent hydrogen is due to the fact that the gas is in the atomic state. This, of course, is mere hypothesis, and it is practically impossible to test its truth. Further, it is also hypothesis to assume that atomic hydrogen is more active than molecular hydrogen, and lastly, this "explanation" leads to the deduction that nascent hydrogen from different metals must be the same and possess exactly the same powers. Such is, however, by no means the case. We know that nascent hydrogen from some metals will perform reductions which the nascent gas from other metals will not, and it is a general empirical rule that the higher the metal in the Electro-motive Series the greater the reducing power of the nascent hydrogen developed at its surface.

Let us consider a moment what is the driving force which causes the liberation of hydrogen. It is the difference in position of the metal and hydrogen in the Electro-motive Series. We can regard the hydrogen as being ejected from the acid under a very considerable pressure, a pressure which is all the greater the higher the position of the metal in the series. According to this view "nascent" hydrogen is practically hydrogen under very great pressure, and it is interesting in this connection to call attention to the fact that ordinary hydrogen under great pressure can deposit silver from solution, which hydrogen at atmospheric pressure does not do. A simple analogy makes the matter perhaps clearer, at any rate, to the junior student's mind. If we imagine a crowd of people trying to get out of a room with a very narrow door, then, owing to the pressure of the people behind, those in front are projected through the opening with a velocity depending on the magnitude of this pressure. This pressure behind is dependent on the tendency of the persons to get outside, and corresponds to the ionisation tendency of the metal. The ejected people, again, correspond with the nascent hydrogen. Owing to their energy of ejection they have different properties to people at rest, *i.e.*, possess more energy.

Thus nascent hydrogen developed at the surface of metals high up in the Electro-motive Series possesses more energy than that from metals lower in the series, and this energy is available for the reduction of any reducible body present.

We can apply this principle to the action of nitric acid on metals. When a metal is placed in dilute nitric acid, then, if the metal can displace hydrogen, it proceeds to do so, and develops "nascent" hydrogen. This at once reduces the acid, and how far the reduction goes, or what products are formed, depends chiefly on the available energy of the nascent hydrogen, *i.e.*, on the position of the metal in the Electro-motive Series.

With those metals at the top of the series, *i.e.*, K, Na, Ca, and Mg, it is conceivable that the hydrogen is displaced at such a very great pressure that some of it escapes oxidation, and so there may be small quantities of free hydrogen among the gaseous products. The chief product of reduction of the HNO_3 will, however, in such cases be ammonia, *i.e.*, the maximum possible reduction. With metals somewhat lower in the series nitrogen, N_2O and NO will be the chief products, the relative amounts of each depending upon the conditions of temperature and concentration.

But what about those metals which have no tendency to displace hydrogen from solution? These metals cannot assume the ionic form directly by displacing hydrogen from its union with an electric charge. They may, however (if their tendency to oxidation is great enough), be oxidised directly by the nitric acid to oxide, which then dissolves in the acid to form a salt. In this way the tendency of the metal to form ions is satisfied. Even with the metals below hydrogen, however, there is still a very different tendency towards oxidation corresponding to the position in the series. Copper is oxidised more readily than silver, and silver again more readily than gold. Hence the possibility of "parting" gold and silver is really a consequence of difference of position in the Electro-motive Series. As regards the gaseous products of reduction in the case of metals below hydrogen, the HNO_3 will not be reduced as far as is the case with metals higher in the series. Hence we should expect chiefly NO and NO_2.

Thus the different metals, with nitric acid of medium concentration, will give products as below:

K Na Ca Mg	Al Zn Fe	Sn	Pb H Hg Cu Ag	Pt Au
H_2, NH_3	NH_3, N_2, N_2O	N_2O, NO	NO, NO_2	No action.

There may, of course, be secondary reactions, *e.g.*, the reoxidation of some of the products by the nitric acid if this be concentrated. As regards primary products of reduction, however, the conceptions already developed may, in conjunction with the law of mass action, help us to predict the general effect of concentration of acid and accumulation of reaction products. Just as nascent hydrogen can reduce nitric acid to ammonia more readily when at a high generation pressure than when at a lower, so also nitric acid is more powerful as an oxidising agent when concentrated than it is when dilute. Hence for a given oxidation by nitric acid the concentrated acid will be reduced to a lesser degree than will a dilute acid. For any given metal, then, we should expect dilute nitric acid to give a lower reduction product than a concentrated acid. Thus it is that some metals on treatment with dilute acid give chiefly ammonia, whereas with a more concentrated acid N_2O or N_2 may be the chief product of reduction.

Moreover, the metal as it dissolves in the acid does so in the ionic form. According to the law of mass action the greater the concentration of metal ions in solution the more difficult does it become for more of the same ions to enter the solution. Hence an accumulation of metallic nitrate in the system makes the metal appear to have a less tendency to enter the ionic condition, that is, the metal then acts as if it were lower in the Electro-motive Series than it really is. The reducing power of the nascent hydrogen developed at its surface thus becomes less, and consequently products of reduction containing more oxygen are formed. Thus from a metal which gives chiefly NO at first, the accumulation of metallic nitrate may give rise to increasing amounts of NO_2. This tendency, however, may be balanced more or less by another complication, *viz.*, that as the reaction proceeds the acid is becoming more dilute. Not only is this because the acid is used up in oxidising nascent hydrogen, and in forming metallic nitrate, but water is being produced which continually dilutes the acid. Hence the acid becomes very rapidly more dilute and, as we have seen above, this means in general the production of products of a lower state of oxidation.

This latter consideration may out-balance the former, and so some metals which at first produce chiefly NO, when acted on by nitric acid may give chiefly N_2O as the reaction proceeds.

This production of water may be of much greater importance in the action of acids on metals than is generally thought to be the case. To put the matter in the form of a question, let us ask, "Why does not moderately concentrated nitric or sulphuric acid act upon certain metals, whereas a more dilute aid reacts immediately?" That such is often the case is very quickly observed by students during the preparation of nitrates from metals. Lead forms a very good example. One explanation, and the one generally given, is that the metallic nitrate formed is insoluble in concentrated acid and forms a protective covering over the surface of the metal. There may be, however, much more in the matter than this. I should like to suggest an explanation which I have not previously heard expressed. Although not perhaps suitable as an explanation to a young student, yet it may possess a certain amount of interest.

There are many facts in connection with the strong acids which point to the conclusion that they undergo chemical combination with water. The heat evolution and the contraction on mixing with water are arguments in favour of this conclusion, and moreover in certain cases definite hydrates have been actually isolated.

If such combination does really take place, and if one hydrate largely predominates in the solution, as is very likely, then the law of mass action demands that at some definite concentration of acid, the concentration of the hydrate must be a maximum. The actual composition of the mixture at which this occurs depends on the formula of the hydrate. Addition of either pure acid or water to acid of such a composition means a decrease in the *concentration* of the hydrate, although not necessarily a decrease in the actual amount of hydrate formed.

On one side of this maximum we have practically a solution of hydrate in water, and on the other side a solution of hydrate in pure acid. The two media may be thus quite different, and hence a concentrated acid may show quite different properties to a dilute one.

From this standpoint it is no surprise that a concentrated acid may not act on a metal, whereas the addition of water may cause the action to proceed.

The matter may be considered a little further. Suppose that combination with the solvent precedes ionisation. This is a view that is being adopted by many adherents of the ionic theory. Ionisation can then take place only when the dissolved substance can combine to a greater or less extent with the solvent. The converse is, of course, by no means true. Where there is combination between solvent and solute this does not necessitate ionisation.

If we assume that it is the compound which ionises, *i.e.*, the hydrate, then the law of mass action requires that the cancentration of ions shall be proportional to the concentration of hydrate in the solution. Hence in such cases since the concentration of the hydrate reaches a maximum at some point, the concentration of the ions must also pass through a maximum. If this is so, then all such acids must possess a maximum specific electrical conductivity. As we know, this is the case with all the strong acids. It is of interest to note that Gibson* has emphasised the fact that the strong acids, particularly the halogen acids, have very different properties, according as their concentration is greater or less than that corresponding to maximum specific conductivity.

Consider now the solution of nitric acid which has the maximum ionic concentration, *i.e.*, the maximum concentration of hydrate. Addition of more pure acid means the dilution of the system with pure acid. We have now practically a solution of hydrate in pure acid, and since the pure acid is nothing like so good an ionising medium as water, the concentration of ions must decrease very rapidly. In such a medium the tendency of a metal to assume the ionic condition will be very much less than in an aqueous solution, and in fact there will soon come a point where the metal is no longer able to send ions into the solution. From there onward the acid has no action on the metal.

If the concentration of the acid be still further increased the metal may assume the passive state. This is, however, quite another matter, and one which is not yet quite satisfactorily explained.

* *Trans. Royal Soc. Edin.*

In the present paper I have endeavoured to show that the Electro-motive Series affords a valuable aid to classifying the metals with regard to many of their fundamental chemical properties. The matter is in general not new, but it seems sufficiently important from a teaching standpoint, to be thought out and put into print. It will be found that practically every property of a metal dealing with its tendency to salt formation can be better correlated by means of the Electro-motive Series than by the aid of the Periodic Classification. To the advanced student of chemistry the value of a thorough understanding of the Electro-motive Series is even greater, since the ionisation tendencies can be expressed in actual figures. It may be that the final classification for Inorganic Chemistry will be one resting on the principles of energy. In such an ideal classification every reaction would be characterised by a definite numerical value representing its driving force, instead of by the vague term, affinity, or tendency, as it has to be at present. Such a system, however, will be based on electrical measurements, and will be a later development of the classification, according to the Electro-motive Series.

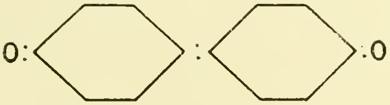
Le Vaillant's Grotto.—In the January issue of the *Geographical Journal* (vol. 39, pp. 40-47) an interesting description of the grotto at Heerenlogement, nearly 20 miles north-west of Clanwilliam, where le Vaillant inscribed his name in 1783, is given by Prof. H. H. W. Pearson. Amongst other illustrations the article has a photograph of part of the north wall of the grotto, where, in addition to the name of the celebrated South African traveller, some other well-known names appear, including Andrew Geddes Bain (1854), Baron von Ludwig (1853), and Zeyher (1829). Dr. Pearson remarks regarding the condition of the grotto:—

"It is used as a shelter for stock, and some of the inscriptions are so worn down by friction that they are now almost obliterated, and of the few who have visited it in recent years a considerable proportion have felt impelled to inscribe or paint their own names on the walls at the risk of confusing the earlier and more interesting records. The situation of the cave renders any adequate measure of protection exceedingly difficult, if not impossible, and there is every probability that before many years have passed, it will have lost the principal feature of the interest which it possesses to-day."

The names of Van der Stel, Ecklon, and Zeyher are curiously misspelt in Dr. Pearson's article.

NEW DERIVATIVES OF DIPHENOQUINONE, AND A NEW VARIETY OF STEREOISOMERISM.

By James Moir, M.A., D.Sc., F.C.S.

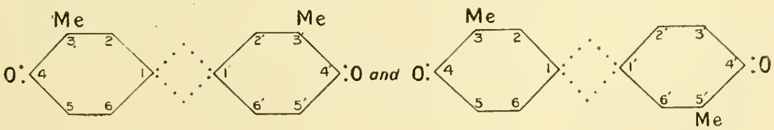
Diphenoquinone, 

was discovered in 1905 by Willstaetter and Kalb (*Berichte*, 1905, 1232), who remarked at the time on its considerable differences from cœrulignone (which is supposed to be its tetramethoxy-derivative), but satisfied themselves that it really is the parent-substance of the latter, despite its unique properties. Not having been quite satisfied on this important point, the author has for some years been investigating the cœrulignone family, and in particular the methyl-derivatives of diphenoquinone, which he finds to be obtainable in good yields by simpler methods than those necessary in the case of diphenoquinone. The starting material is *o*-*o*-dicresol (3-3′ dimethyldiphenol-4-4′) for the oxygenated bodies, and tolidine (3-3′ dimethylbenzidine) for the imino-derivatives of the quinone. The present paper deals only with these new derivatives, and the cœrulignone question will be discussed when the full evidence has accumulated.

A. *Dicresoquinone* (3-3′ dimethyl-diphenoquinone) has been obtained in two apparently stereoisomeric forms, corresponding respectively to the following structures.*

Three methods of preparation have been successful. The first is Willstaetter's general method, namely, boiling dicresol with ten times its weight of lead peroxide in benzene for ten minutes, filtering and cooling. The product is the trans-form, a network of very fine deep-yellow needles devoid of metallic lustre (*cf.* cœrulignone). It melts at 163° with decomposition, and "*verpufft*" if fairly rapidly heated. In all other respects, including solubilities, it resembles Willstaetter's yellow modification of diphenoquinone. Acetone, ethyl-acetate and benzene are the only solvents which dissolve it appreciably. Stannous chloride in hydrochloric acid reduces it almost instantaneously

* The author has a recollection that this type of isomerism was predicted by H. E. Armstrong in 1901, but it does not seem to have been published.



3-3′ or Cis-Form (red), m.p 148°. 3-5′ or Trans-Form (Yellow), m.p. 163°.

The dotted bonds between the rings indicate that they lie n a plane perpendicular to the paper, on which fact the isomerism dep nds.

to dicresol. The latter, obtained in this way, melted at 157° without purification, and was therefore the sole product. 0.0567 when treated with a weighed quantity of normal tin solution till white, and then titrated back with iodine, used 0.0314 tin; hydrogen used in reduction = 0.93%. Theory calculated from formula $C_{14}H_{12}O_2$ = 0.945%. The needles of trans-dicresoquinone possess "straight-extinction."

The cis-form is obtained by treating a solution of dicresol in excess of glacial acetic acid at 40° with solution of half its weight of CrO_3. The solutions must be suddenly mixed, when the quinone comes out at once, in fairly stout deep-red needles. It is washed with acetic acid in which it is practically insoluble, and then with water to remove the latter, which would otherwise cause partial decomposition during drying. Cis-dicresoquinone thus prepared is brick-red like phenanthraquinone, and in bulk has an extremely faint pink lustre, much fainter than that of Willstaetter's dark variety of diphenoquinone. The author suspects that this substance of Willstaetter's owes its lustre to a trace of its quinhydrone; Willstaetter publishes no reduction-analysis of it.

Under the microscope the needles are seen to be complex and do not exhibit any consistent extinction to polarised light, even in intense illumination.

The acetic acid method is rather tricky, as when the temperature is too low the product contains the quinhydrone and is greenish-brown, and when too hot the product is impure and the yield bad. Under the right conditions the yield is 97%. When the red variety was reduced by stannous chloride (not instantaneous) the product, washed with the minimum quantity of water in a Gooch crucible, amounted to 97% of the quinone taken, melted at 157°, and was therefore pure dicresol.

Both varieties resist sodium hydrate, thus differing from cœrulignone and the allied substances.

The third method of preparation yields a mixture of the two varieties, the yellow predominating. Dicresol is dissolved in hot water with a little alcohol and treated at about 80° with excess of a ferric salt in acid solution, and digested till the olive colour of the quinhydrone changes to orange and the whole precipitate is microcrystalline. The yield is theoretical: the crude product melts indistinctly at about 152°. 0.1302 used 0.0695 tin. Hydrogen for reduction = 0.96%, and the dicresol obtained melted correctly. The mixture is dark-orange in bulk.

All three preparations give the same reaction with concentrated sulphuric acid, namely, a deep brown-orange coloration, similar to that given by diphenoquinone (see end).

Some success was met with in the attempt to change the modifications into each other, but as they are sensitive to heat and very sparingly soluble, it was not possible to perform the experiments on a large scale. When boiled with chloroform, the red variety decomposed, and only a black "mess" was obtainable, but when dissolved in carbon tetrachloride at 50° and evaporated in a thin layer in the cold it gave a network of sulphur-yellow needles with straight-extinction. When the same experiment was tried in acetone, the product recovered was unchanged. Conversion was also obtained by dissolving the red variety (m.p. 148) in ethyl acetate at 40°, adding alcohol and then water to turbidity: the very minute pale needles thus obtained melted with decomposition at 161-162°. On the other hand, hot acetone slowly converts the yellow variety into the red, the melting-point changing from 163° to about 140°, but the deep-red crystals obtained probably contain some quinhydrone, as they have a bluish lustre.

B. *Dicresoquinhydrone* (*dicresoquinone-dicresol*), $C_{28}H_{26}O_4$, is obtained by adding ferric chloride, not in excess, to a solution of dicresol in much cold dilute alcohol. An interval of half-a-minute elapses before the reaction commences, but in a few minutes the whole of the organic substance is precipitated in very fine microcystalline form, with a brilliant green reflex, so that the suspension resembles alkaline fluorescein. Under the microscope the transmitted colour is a sort of olive brown, and the reflex grass-green. With concentrated sulphuric acid it gives an intense blue coloration (*cf.* diphenoquinhydrone and cœrulignone). It cannot be recrystallised, though comparatively soluble in alcohol and acetone. Hot alcohol dissociates it completely, dicresoquinone being left insoluble in orange needles, although dilution with water causes a partial recombination. 0.2815 treated with 0.1937 tin in 5% solution used 11.33cc. $\frac{N}{5}I_2$: H = 0.36% for reduction (sample washed out with dilute alcohol and dried over sulphuric acid in vacuo) : $C_{28}H_{26}O_4 + H_2$ requires H = 0.47%. The product is not perfectly white and melts 8° too low for dicresol, but nothing else could be recognised under the microscope.

Only a poor yield of the quinhydrone is obtainable from dicresol and dicresoquinone in benzene solutions, no reaction occurring for some time, and other amorphous substances being formed. On the other hand, a fairly satisfactory specimen of the quinhydrone is obtained when dicresoquinone is digested with warm bisulphite solution and a trace of alcohol: of this 0.1003 + 0.0935 tin used 5.8 cc. $\frac{N}{5}I_2$; H = 0.41% for reduction. It is still, however, possible that dicresoquinhydrone is not a simple addition-product, but our present methods of analysis cannot decide between such closely approximating formulæ as $C_{28}H_{26}O_4$ and $C_{42}H_{40}O_6$ for example.

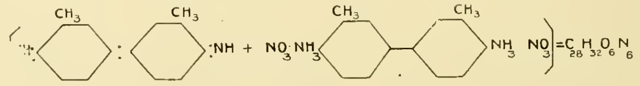
When covered with a very little strong caustic soda, a beautiful blue-purple sodium salt is obtained, which decomposes on adding water. It could not be obtained by the other methods described by Willstaetter for sodium-diphenoquinhydrone—only mixtures of dicresol and its quinone resulting.

C. *Dicresiminoquinone* (3-3′ *dimethyldiphenoquinonediimine*) is obtainable by oxidising tolidine by Willstaetter's method, but the product (very dark red granules with faint blue lustre, m.p. 158-160°) is unsatisfactory. It gives a purple coloration with sulphuric acid and is reduced by stannous chloride with great difficulty to tolidine and another (unidentified) substance. The amount of tin used in the reduction is only threequarters of the theoretical. All its properties suggest that it is an azo-dye produced by polymerisation of the original diimine.* The same applies to Willstaetter's diphenoquinonediimine.

D. *Dicresiminoquinhydrone* (*quinhydronic combination of true dicresiminoquinone and tolidine*) is, however, easily obtained as a nitrate. Tolidine is dissolved in a little over the theoretical amount of nitric acid and excess of water at 70° and treated with excess of ferric nitrate solution. The new substance crystallises out almost at once and is filtered off on cooling, and washed in a thin layer on a Buchner funnel with a minimum of water, as it hydrolyses easily to an amorphous basic nitrate. This remarkable substance forms very deep blue-violet needles, quite opaque even in sunlight unless powdered, with a bronze-coloured metallic lustre. It decomposes at 240° without melting. It dissolves in warm water to a deep blue solution which then deposits the basic nitrate as a greenish-blue scum with copper lustre. In dilute acid it dissolves to a yellowish-brown, becoming deep green on dilution. Stronger acids dissolve it to the pure yellow colour attributable to the diimine itself. All the solutions decompose on boiling and produce a violet azo-dye. Concentrated sulphuric acid gives a deep orange-yellow, which stands dilution and even boiling : the diimine is evidently stable when combined with excess of acid. Iron and water of crystallisation were found to be absent.

0.1960 used 3.90 cc $\frac{N}{10}$ $SnCl_2$: H = 0.40%. ⎫ Tolidine was the
0.4410 used 9.05 cc $\frac{N}{10}$ $SnCl_2$: H = 0.41%. ⎭ reduction-product.

0.6940, boiled with caustic soda and worked up with "nitron" acetate, gave 0.8910 "nitron" nitrate HNO_3 = 21.6 %, probably 22.5%, allowing for the solubility of "nitron"-nitrate. The formula

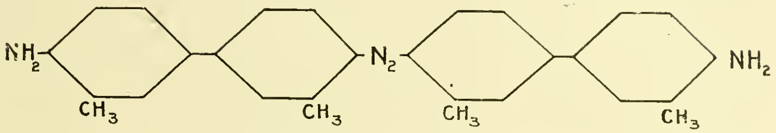


requires H = 0.36%, HNO_3 = 23.0%.

The azo-dye resulting from boiling this with water was amorphous and too insoluble to investigate: it gives a very fine crimson coloration with sulphuric acid, and its salts are soluble

* See Willstaetter *loc. cit.* and Moir, *Trans. R.S.S. Afr.* 1911.

in hot water to a deep purple colour. Its constitution is, very probably,



The *basic nitrate* of the above quinhydrone is obtained as a fine purple precipitate by dissolving 4 grams of tolidine in 100 cc N.HNO_3 and 400 cc of water and adding just over the theoretical quantity of chromium trioxide (from $3C_{14}H_{16}N_2 + 12\ HNO_3 + 2CrO_3$). The precipitate can be washed despite its gelatinous character, on a Buchner funnel, and has a brilliant copper lustre. Dried over sulphuric acid in vacuo and analysed as above. Found Cr = 0.66% (adventitious); H for reduction 0.44%; HNO_3 = 8.1%.

This substance is of the same class as the so-called "benzidine chromate,"* which has been shown to be the dichromate of dipheniminoquinhydrone (=benzidine+diphenoquinonediimine). The analogous substance in the tolidine series is obtained as above, using *excess* of potassium chromate instead of CrO_3. It is identical in appearance with "benzidine chromate," but blackens on drying owing to some internal oxidation.

0.6381 gave 0.1498 Cr_2O_3 — Cr = 16.1%
$C_{28}H_{32}N_4Cr_2O_7$ requires Cr = 16.25%

The substance is *dicresiminoquinhydrone dichromate.*

The heated substance contains a polymerised base giving a maroon colour with sulphuric acid, instead of the yellow given by the original (presumably the same as the above-mentioned azo-dye).

E. *Dibromodicresoquinone* (5-5′ *dibromo-* 3-3′ *dimethyl-diphenoquinone* and its stereoisomer 3-5′ *dibromo-* 3′-5 *dimethyl-diphenoquinone*) is obtained by similar methods to that described for dicresoquinone, by oxidising 5-5′ dibromo-dicresol† in various ways, but the dark variety (presumably the 5-5′ dibromo- or *cis* variety) is that generally obtained. By using two parts of dibromodicresol and one part of CrO_3 in excess of warm glacial acetic acid and filtering off as soon as the quinone separates, it is obtained in bright scarlet needles with a very faint green metallic lustre. Under the microscope the substance forms complex bundles of blood-red needles without extinction. When heated in a melting point tube it decomposes suddenly to a pale substance at 194°. Caustic soda does not affect it until after prolonged exposure, when the beautiful indigo-like sodium salt

* See Moir: *Proc.* 1906, 258 and *Trans.* Roy. Soc. S. Afr., 1911.
† *Trans.* 1907, 1310.

of its quinhydrone eventually results. It is considerably more soluble in organic solvents than dicresoquinone.

0.2218 used 11.99cc $\frac{N}{10}$ Ag (see *Proc.* 1906, 262 and 1907 No. 330) – > Br = 43.25%

0.0838 used 2.62cc $\frac{N}{5}$ $SnCl_2$ by difference against a blank, both done in presence of alcohol—H = 0.55%

$C_{14}H_{10}O_2Br_2$ requires Br = 43.2, H = 0.54%

The reduction-product is pure dibromodicresol, *m.p.* 184°, and an almost quantitative yield can be obtained, as it is practically insoluble in cold water.

Magatti's method—addition of a few drops of yellow nitric acid to the acetic acid solution of dibromodicresol—was also tried; the product was similar in appearance, but the bromine analyses were all low. It has also been obtained by two aqueous methods: (a) dibromodicresol is converted into a gelatinous form by solution in soda and addition of mineral acid; on boiling this with excess of ferric salt and then adding a little CrO_3, the substance changes through the olive quinhydrone into the microcrystalline quinone: it is boiled to complete the crystallisation, and after collecting washed with 50% alcohol to dissociate any trace of quinhydrone. Found in this specimen, a brick-red crystalline powder, 44.01% Br: (b) the jelly above described is boiled with acid and a mixture of (KBrO + 5KBr) in solution gradually run in. Found 43.98% Br. The yields in both cases are about 95%.

All the specimens give with concentrated sulphuric acid a scarlet coloration, fuchsine-red when only traces are taken. The spectrum of this is indefinite, being a broad absorption-band over the whole of the green, deepest between b and F.

What appears to be the *trans*-variety of this compound is obtained by boiling it with acetone and then diluting with alcohol and water to turbidity. The crystals are tiny salmon-coloured lozenges showing a slightly oblique extinction and melting with decomposition at 185°.

On boiling dibromodicresoquinone with bisulphite the quinhydrone is obtained in a few minutes, but about ten hours are necessary to reduce this to dibromodicresol. The aqueous solution then contained some ionic bromine, showing that, as in the case of Magatti's "tetrabromodiphenoquinone"* some of the bromine is loosely held in the strained benzene rings.

F. *Tetrabromo-dicresoquinhydrone* (dibromodicresoquinone + dibromodicresol) is best obtained by adding an acetic acid solution of chromium trioxide drop by drop to solution of dibromodicresol in acetic acid at 50°, avoiding excess of oxidant.

*Proc., 1906, 110.

The nearly black crystalline product is filtered off at once and washed with acetic acid and a little alcohol. It forms black needles or flat hexagons with a lustre like that of graphite, melting with decomposition at 165-170° according to the rate of heating.

0.2223 gave 0.2281 AgBr — Br = 43.6%.

0.0905 used 0.90cc $\frac{N}{5}$ $SnCl_2$ against a blank—H for reduction = 0.20%.

$C_{28}H_{22}O_4Br_4$ requires Br = 43.1, H = 0.27%.

As prepared by the action of ferric salts on the dilute alcoholic solution of dibromodicresol, it is obtained in fine division, showing a chocolate-brown transmission colour and an intense blue-green lustre.

It is also obtainable by adding a little bromine to an acetic acid solution of dibromodicresol at 60° : black tabular crystals with green lustre; the mother liquor contains the quinone and possibly the perbromide described by the author.* For analysis it was ground in an agate mortar and boiled with standard stannous chloride and an excess of acetone till colourless : 0.1447 used 0.0267 tin : H for reduction = 0.31% : on diluting, the whole of the reduction-product was obtained in crystalline form, melting at 182-4°, therefore practically pure dibromodicresol.

On boiling the quinhydrone with alcohol or acetone, it is gradually completely dissociated and the quinone crystallises out : on diluting the orange mother-liquor, the quinhydrone is, however, partly re-formed.

Tetrabromo-dicresoquinhydrone gives a fine blue coloration with sulphuric acid, which developes a red edging on standing. Its alkali salts can be obtained by rubbing it up with a trace of very strong alkali, but is decomposed by water : bright blue gelatinous substance, with brilliant coppery lustre : it was not obtained on treating disodium-dibromodicresol with iodine or ferricyanide—only mixtures of the quinone and the unoxidised substance resulted.

On oxidising an acetic solution of a mixture of monobromo- and dibromodicresol (the product of a bromination of dicresol where, owing to too low temperature and "protection," the action was incomplete; *m.p.* 161-3°), *tribromodicresoquinhydrone* was obtained: black graphitic needles : found 34.6 and 35.7% Br, and H for reduction = 0.25%.

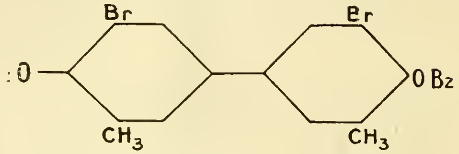
$C_{28}H_{23}O_4Br_3$ requires Br = 36.2, H = 0.30.

On boiling with acetone, the corresponding quinone or mixture of quinones was left : red microscopic needles, apparently uniform; Found Br = 35.1%.

* *Trans.* 1907, 1311.

G. New substances.

(1) *Dibromodicresol dibenzoate,*



obtained by the Schotten-Baumann method, forms white granules, insoluble in alcohol, fairly easily in ether, melting at 239°. Found Br = 27.3%.

$C_{28} H_{20} O_4 Br_2$ requires Br = 27.6%.

Owing to "protection," it can only be hydrolysed by fusion with solid potash: the dibromodicresol recovered gave 44.1% Br, and had therefore its bromine intact.

(2) *Dibromodicresoldiacetate,* which forms boat-shaped needles m.p. 198°, yields on oxidation with excess of CrO_3 in boiling acetic acid a benzenoid bromo-acid, which after hydrolysing off its acetyl group, was converted into (3) 5 *bromo-* 3 *methyl-* 4 *oxybenzoic acid.* This is almost insoluble in water and melts at 233°. Found 35.2% Br.

$C_8 H_7 O_3$ Br requires Br = 34.6.

It is curious that Beilstein's Supplement II. describes an isomeric *bromoxytoluic acid*, with the same properties and melting point : possibly these are identical instead of isomeric.

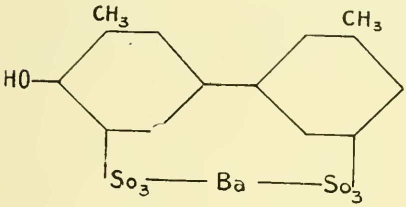
(4) 5-*bromo* 5′ *nitrodicresol* (5 *bromo* 5′ *nitro*-3-3′ *dimethyl-diphenol*) : bye-product in preparation of dibromodicresoquinone by Magatti's method, also directly by treating dicresol in acetic acid first with bromine and then with yellow nitric acid : deep orange needles, m.p. over 260° : potassium salt brick-red and almost insoluble. Found 22.7% and 23.0% : $C_{14}H_{12}O_4$ NBr requires Br = 23.7%.

(5) 5-5′ *dinitrodicresol* can be made in one step from tolidine in boiling acetic acid by adding strong nitric acid, boiling in a capacious vessel, diluting, and hydrolysing the dinitrotolidine with strong caustic soda. Very dark chesnut brown substance very sparingly soluble in all solvents and charring at about 320°. The attempt to make 5-5′ diamino-dicresoquinone from this failed : the insoluble product was amorphous and gave a dirty-brown with sulphuric acid.

(6) *Dicresoldisulphonic acid.* When dicresol is heated with sulphuric acid at 100°, the main product appears to be a *monosulphonic acid* : a small quantity was obtained in sparingly soluble white needles, which swell up on heating but do not melt. To obtaine the disulphonic acid dicresol is heated with 20 parts of $H_2 SO_4$ to 200° for some time, and the product worked up with barium carbonate in excess as usual. The barium salt is somewhat soluble, as is also the free disulphonic acid, so that the solution was induced to crystallise by adding barium acetate, the

barium salt forming lustrous prisms arranged in rosettes. Dried over calcium chloride 0.1195 lost 0.0067 at 150° and gave 0.0510 $BaSO_4$

Found : $H_2O = 5.6\%$, $Ba = 25.1\%$.



$+ 2H_2O$ requires $H_2O =$ 6.6, $Ba = 25.2\%$.

This acid gives a bright blue coloration with ferric chloride and a deep orange with chromium trioxide (oxidation to sulphonic acids of dicresoquinhydrone and dicresoquinone).

H. Halochromism of the Diphenoquinone Series.

The following table exhibits the halochromism to H_2SO_4 of all the known derivatives of the cœrulignone family.

Name as derivative of Diphenoquinone = D.	Transmitted Colour.	Reflected Colour.	Coloration with H_2SO_4	Remarks.
D (Willstaetter) ..	Orange red	Faint bluish	Orange-brown	Greenish on dilution
Dimethyl-D (Moir) ..	,,	Nil	,,	No change
Tetramethyl-D (Auwers)	Red	Bluish	,,	,,
Tetrabromo-D (Moir)	,,	Pract'ly nil	,,	,,
do. (Magatti)	Garnet-red	Blue	Crimson	Yellow on dilution
Tetramethoxy-D (Coerulignone) ..	Brown red*	purple	Royal-blue	Red on dilution
Dibromodimethyl-D (Moir)	Scarlet	Faint green	Scarlet	Yellow on dilution
Tetrahydroxy-D (Liebermann)‡ ..	Dark-blue			
Tetraamino-D (Kunze)	Red-violet*	Olive	Olive	
Diphenoquinonediimine Willstaetter) ..	Red	Purple	Blood-red	
Dicresoquinonediimine (Moir)	,,	,,	Crimson-purple	
Diphenoquinhydrone..	Black*	Olive	Violet-blue	
Dicresoquinhydrone (Moir)	,, *	,,	Royal-blue	
Tetrabromo do. (Moir)	,, *	,,	,,	With red edge
Dicresoquinhydrone-tetraimine nitrate ..	,, *	Bronze	Orange-yellow	
Hydrocoerulignone ..	Nil	Nil	Deep-orange†	Stable on heating

* Almost opaque even in sunlight.

† This is an extraordinary anomaly, as the formation of a quinonoid oxonium salt is excluded : it is not due to an impurity, and the HCl oxonium salt is white.

‡ The author has been unable to make this substance.

OBSERVATIONS OF ATMOSPHERIC ELECTRICITY AT BLOEMFONTEIN.

By Prof. William Arthur Douglas Rudge, M.A.

On pages 232 to 237 of this volume some account is given of observations on atmospheric electricity at various places in South Africa. The present communication gives some details of daily observations carried on at Bloemfontein for a period of nearly three months.

The objects of the experiments were to ascertain (1) the daily range of the potential gradient, (2) the time of the maximum potential, (3) the relation, if any, between the variation in the potential gradient and the barometrical pressure.

The apparatus used in the couse of the investigation consisted of an electroscope with a double wall, as devised by C. T. R. Wilson. The gold leaf system was insulated by a quartz tube, and to the end of the wire carrying the gold leaf there was attached a brass plate 5 cms. in diameter coated with a radium preparation. As is well known an insulated metal plate exposed in the open air tends to take the potential of the layer of air immediately in contact with it, and this tendency is considerably accentuated by attaching to the plate either (*a*) a small piece of burning tinder, or (*b*) a vessel from which water is dropping, or (*c*) covering the plate with a weak radioactive substance. This latter method is the most convenient, but perhaps not the best, unless Ionium is the radioactive material used, however, if comparative values only are required, the radium coated plate is in every way satisfactory, provided the radium preparation is not very strong, as in that case the intense ionisation of the surrounding air causes the acquired charge to be quickly lost.

The observations were taken near the Grey University College, but in such a position that the buildings had no influence. The electroscope was placed so that the collecting plate was at a height of 140 cms. from the ground, and observations were taken as times permitted, between 6 a.m. and 12 p.m. These of course were not continuous, but when it was seen that the potential was changing, a close watch was kept.

As pointed out in a previous paper, there are two daily maxima, one in the morning and the other in the evening. The times of these maxima are not very regularly fixed, but this is due probably to winds and dust. If the atmospheric conditions were always uniform it is likely that the times would be more uniform.

In general a day's observations show the following changes in the potential gradient: From early morning until sunrise the gradient is low, rising after sunrise, and steadily increasing until the maximum is reached, then falling fairly rapidly to a value which remains steady over many hours, and then rising to the second maximum. A drop follows this, and before midnight, as a rule, it has dropped to the lowest value, and remains fairly constant until sunrise, as shown by the curve given in the paper referred to.

The chief factors which modify the electrical charge are mist and dust, from natural causes, and steam and smoke from what may be termed causes due to civilisation. Attention has been paid to these factors in the course of the work, and their general effects are stated below. The normal electrification of the air is positive during fine weather.

Disturbing influence.	*Effect on + charge.*
Mist.	Increases its value.
Dust.	Diminishes ,, ,,
Steam.	Increases ,, ,,
Smoke.	Increases ,, ,,
Rain.	Decreases ,, ,,

It must be pointed out that rain is sometimes positively charged, but in this country it is generally negative.

The effects of steam and smoke are noticeable only in towns or near railways, but the other three factors make their influence felt anywhere. The effect of dust is more marked than that of mist.

A day's observation will indicate how the value of the electrification is changed by the various disturbing factors:—

	Potential gradient.	Nature of Charge.
Just before sunrise, slight mist.. ..	50	+
Just after sunrise, slight mist	58	
7.30 Thick mist	400	+
8.0 Thick mist	200	+
8.30 Mist clearing..	68	+
9.0 Sky clear	85	+
9.30	60	+
10.0	40	+
10.30		
11.0	38	+
4.0	38	+
5.0 Wind from N.W., accompanied with dust..	50	—
5 to 6 Intermittent clouds of dust ..	over 400	—
6.30 Wind dropped	50	—
6.40 Wind dropped		
6.50 Rain falling	over 400	—
7.0 Rain falling	over 400	—
7.10 Rain falling	over 400	—
7.30 Rain ceased	60	+
8.45	40	+
10.15	45	+
11.0	58	+
11.30	45	+
12.0	45	+

From 11 a.m. to 4 p.m. the value was practically constant.

Dust and rain thus have the effect of completely reversing the normal electrical charge in the atmosphere. The reversal due to the rain is undoubtedly caused by the breaking up of larger drops into smaller ones, either by collision or by internal stresses set up by the drop falling through the air. The breaking up of water by mechanical means into fine spray is always accompanied by a strong negative electrification of the air, as was shown by a series of observations taken at the Victoria Falls (see *Phil. Mag.*, May, 1911).

The effect of a "dust devil" may be perceived at a considerable distance from it, as the following extract from the observation shows:—

August 20th.—Windy; atmosphere misty until 8.50; potential gradient rose to maximum at 9.25, fell rather rapidly to 15 at 10.30; varied between 10 and 15, until 12, when it suddenly fell to zero. A "dust devil" was seen at Tempe, about two miles away. It circled round and finally worked itself out, but its influence was recorded by the electroscope, as the table shows:—

Time.	Pot.	Charge.
11.50	18	+
12.0	0	0
12.3	150	—
12.5	300	—
12.10	120	—
12.12	0	0
12.14	20	+
12.30	50	+
1.0	50	+
1.35	50	+
2.15	50	+

The rest of the day was normal.

The cause of the electrical field surrounding the earth under normal fine weather conditions is somewhat difficult to trace, and various theories have been advanced to account for it. It is quite definite that during fine weather a current of electricity is passing from the air into the earth, and the origin of the current may be due either to a positive charge in the atmosphere or a negative charge upon the earth. The value of this air-earth current has been determined by C. T. R. Wilson, Gerdien, Simpson, Elster and Geitel, and many others, and has a value of about $5 + 10^{-5}$ E.S. units per square cm. It varies with the altitude because the current is determined from the potential gradient and the conductivity of the air. The potential gradient diminishes with the altitude, whilst the conductivity increases.

Arrangements are being made for carrying on a series of observations on the conductivity of the air and the earth air current.

The following table shows the manner in which the maximum value of the potential gradient varies from day to day.

The time at which the maxima occurred is approximate only as the instrument was not self recording, and it may be out by 15 minutes or so. The maximum barometer readings are also given. The daily variation is very small in Bloemfontein. The potential gradient is given in volts per metre.

The times given in the last column are a.m. unless otherwise stated.

Date	Max Pot. Grad.	Time of Max.	Barometric Max.	Time of Max.	Remarks.
June 21	250	10.0 a.m.	25.86	11	Misty.
„ 23	151	8.0 a.m.	25.81	10	
„ 24	112	8.30 a.m.	25.7	10.30	Cloudy all day.
„ 25	120	9.10 a.m.	25.55	11	
„ 26	150	8.45 a.m.	25.55	12	
„ 27	140	8.30 a.m.	25.76	10	
„ 28	140	8.30 a.m.	25.5	10	
„ 29	180	9.15 a.m.	25.86	10	
„ 30	120	9.0 a.m.	25.84	10	
July 1	113	9.0 a.m.	25.89	10.30	
„ 2	178	9.20 a.m.	25.55	10	
„ 3	80	9.45 a.m.	25.56	11	
„ 4	178	9.20 a.m.	25.9	10	
„ 5	130	9.30 a.m.	25.8	10	
„ 6	107	9.20 a.m.	25.75	11	
„ 7	210	8.25 a.m.	25.7	11.30	Misty at 12 noon; dust storm, P. G. to 160 negative at 12.40.
„ 8	154	8.30 a.m.	25.8	12	
„ 9	48	9.30 a.m.	25.9	9	
„ 10	60	10.0 a.m.	25.86	10	Very Misty; water condensed upon instrument.
„ 11	107	8.30 a.m.	25.8	9	Misty up till 10 a.m.
„ 12	20	8.30 a.m.	25.45	12	Wind and dust, P. G. went to over 400 negative at 12 noon.
„ 13	48	9.30 a.m.	25.5		Rain, at 1 p.m. P.G. 200; rain charged positively.
„ 14	57	10.0 a.m.	25.81	10	
„ 15	108	8.0 a.m.	25.91	11	
„ 16	154	8.50 a.m.	25.9	9	
„ 17	140	9.0 a.m.	25.9	10	

Date		Max. Pot Grad.	Time of Max.	Barometric Max.	Time of Max.	Remarks.
July	18	118	9.0 a.m.	25.55	11	
,,	19	237	9.30 a.m.	25.70	10	Misty.
,,	20	82	8.20 a.m.	25.75	9	
,,	21	90	8.50 a.m.	25.68	11	
,,	22	168	9.5 a.m.	25.68	11	
,,	23	120	8.20 a.m.	25.71	10	
,,	24	146	8.20 a.m.	25.7	10	
,,	25	107	8.30 a.m.	25.63	10	
,,	26			25.64	11	Wet day.
,,	27	237	8.30 a.m.	25.6	10	Air very steamy.
,,	28	170	8.50 a.m.	25.72	12	
,,	29	148	9.0 a.m.	25.76	12	
,,	30	295	9.0 a.m.	25.75	11	Misty.
,,	31	170	9.5 a.m.	25.7	10	
Aug.	1	80	8.20 a.m.	25.7	11	
,,	2	138	9.10 a.m.	25.7	9	
,,	3	151	9.30 a.m.	25.6	10	
,,	4	177	8.40 a.m.	25.55	9	
,,	5	180	9.0 a.m.	25.49	10	
,,	6	75	10.0 a.m.	25.55	10	South wind.
,,	7	88	9.30 a.m.	25.7	10	
,,	8	78	10.0 a.m.	25.83	11	
,,	9	271	8.5 a.m.	25.8	10	Misty, frosty.
,,	10	88	8.0 a.m.	25.6	11	
,,	11	120	8.30 a.m.	25.65	11	
,,	12	88	8.0 a.m.	25.64	11	Dull, cloudy till 10 a.m.
,,	13	75	9.10 a.m.	25.7	11	Bright, clear; Charge always low.
,,	14	400?	8.30 a.m.	25.67	10	Misty frost; high value all day; slight wind.
,,	15	237	8.25 a.m.	25.69	10	Mist over town, when the mist reached College max. effect.
,,	16	72	8.0 a.m.	25.70	11	Low value until 5 p.m., then a dust storm sent leaf to right angles with a negative charge.
,,	17	152	8.30 am.	25.74	11	Low most of the day.
,,	18	237	8.20 a.m.	25.72	11	
,,	19	106	8.0 a.m.	25.71	10	

Date	Max. Pot. Grad.	Time of Max.	Barometric Max.	Time of Max.	Remarks
Aug. 20	178	8.40 a.m.	25.71	10	Cloudy, misty; rain fell at some distance away; leaf jumped to maximum.
„ 21	238	8.30 a.m.	25.72	10	Misty.
„ 22	46	8.30 a.m.	25.66	10	N.-W. wind; dust at Tempe, 11 p.m.; 175 negative.
„ 23	79	8.20 a.m.	25.64	10.30	
„ 24	157	8.30 a.m.	25.53	10.30	1 p.m. dust strong negative charge.
„ 25	20	8.0 a.m.	25.55	11	S.-E. wind.
„ 26	47		25.64	10	S.-E. wind, 12.30 p.m., strong + charge.
„ 27			25.75	11	
„ 28	271	8.35 a.m.	25.5	10	Mist reached College at 8.30.
„ 29	180	8.30 a.m.	25.71	10	
„ 30	78	10.0 a.m.	25.78	10	S.-E. wind, 11.30 dust storm; strong negative.
Sept. 1	150	10.0 a.m.	26.0	9	Very misty.
„ 2	400?	8.40 a.m.	25.95	9	Very misty.
„ 3	400?	9.0 a.m.	28.54	8	Very misty.
„ 4	82	8.10 a.m.	25.70	9	Mist over town, but not near College.
„ 5	45	7.50 a.m.	28.66	10	Thin cloud, no mist.
„ 6	43	8.20 a.m.	25.83	11	9.0 dust storm, strong negative charge.
„ 7	82	7.50 a.m.	25.9	10	
„ 8	71	8.30 a.m.	25.85	10	
„ 9	146	9.0 a.m.	25.78	10	Misty and slight cloud.
„ 10	72	9.0 a.m.	25.68	9	
„ 11	38	8.0 a.m.	25.61	10	
„ 12	40	7.40 a.m.	25.9	11	S.-E. wind, dust devil at a distance nearly O at 8.0.
„ 13	69	8.30 a.m.	25.96	11	

Date	Max. Pot. Grad.	Time of Max.	Barometric Max.	Time of Max.	Remarks.
Sept. 14	69	8.20 a.m.	25.92	10	No wind.
,, 15	101	7.30 a.m.	25.82	9	No wind; mist and cloud; very variable.
,, 16	48	7.30 a.m.	25.75	10	11.30 dust storm, strong negative; 11.40, zero; 12.30, negative.
,, 17	52	7.50 a.m.	25.72	10	Dust most of the day; charge generally negative.
,, 18	52	7.50 a.m.	25.75	10	Dust most of the day, as above.
,, 19	180	7.45 a.m.	25.61	10	Calm, thick mist, variations, but always +.
,, 20	200	8.15 a.m.	25.6	10	
,, 21	80	8.0 a.m.	25.65	10	
,, 22	152	8.25 a.m.	25.66	9	

The table shows the extraordinary daily variation in the value of the potential gradient, and in particular the effect of mist and dust must be noted. Presence of mist always raises the potential and always shows that the charge in the air is positive. Presence of dust at a distance lowers the positive potential, and as the dust approaches gives rise to a negative potential, and the magnitude of the negative potential is higher than that ever reached by the positive potential.* A south or south-east wind is generally accompanied by a low potential gradient. Only the morning maxima are given, and these generally occur between 8 and 9 a.m., but many exceptions can be noted, and the values given in the second column are the positive ones; if a negative charge occurred during the day it is noted in the last column. On no day has the charge been entirely negative, at some time there has been a positive charge. The barometric variations are very normal, and there does not appear to be any connection between the barometric pressure and the variation of the potential gradient. The times of maxima show no relation.

* Save during thunderstorms.

THE SUGAR CONTENT OF MAIZE STALKS.

By George Neville Blackshaw, B.Sc., F.C.S.

The presence of sugar in the juice of maize stalks was known as far back as the year 1519, and mention is made of the manufacture in America of molasses from the juice in the year 1777.

At a meeting of the Linnean Society in 1843, a paper on the manufacture of sugar from maize stalks in the State of Indiana was read by Prof. Croft, who went so far as to affirm that the juice contained three times the sweetening principle of beet, five times that of the maple, and equalled that of the sugar-cane grown in the United States of America. Croft's paper attracted considerable attention, and attempts were made in India to obtain crystallised maize sugar, but without success, the juice after prolonged boiling and subsequent cooling showing no signs of granulation.

The production of a fair quality of syrup in Vermont in the year 1844, and the establishment of a factory in France about 1850 for the production of sugar from maize stalks, are also recorded, the French factory failing owing to the development of the beet sugar industry.

It will therefore be seen that whilst the idea of manufacturing sugar and molasses from maize stalks is by no means new, attempts made to utilise them for the production of sugar on a large scale have hitherto proved unsuccessful.

During the years 1880 and 1881, Dr. Collier, at that time Chemist of the Department of Agriculture at Washington, carried out lengthy investigations into the sugar content of the juice of several varieties of maize, and to his results, which are to be found in a work on Sorghum published by him in 1884, I shall have occasion to refer later in the paper.

In the past the production of maize sugar has never gone beyond the experimental stage; attention has, however, been drawn to the matter again in America by Professor F. L. Stewart, who has for many years devoted much of his time to devising a profitable means of utilising the maize plant for the production of sugar, paper pulp and alcohol. Stewart recently stated in a course of correspondence that whilst the manufacture of sugar, paper and alcohol from maize stalks is not yet fairly established, it had reached a stage of development which gives assurance that wherever maize can be grown to advantage, the three main products—cane sugar, paper pulp and alcohol—are producible from the respective parts of the plant of unexcelled quality, and at a very much lower cost than from any other known source. In a maize-growing country such as ours this is naturally a statement of considerable moment, and demands careful investigation.

Briefly stated, Stewart's process for the production of the raw material consists of removing the cobs in the milky stage instead of allowing the plants to mature their grain; by so doing he maintains, as the result of his investigations, that the cane-sugar content of the juice in the stalks increases to such an extent that "it becomes practically a sugar cane." Stewart further states that, "coincident with this, as a secondary result, and equally important, is the circumstance that there is very little deposition of the hard siliceous matter which forms the outer coating of the maize stalk and becomes incorporated with the peripheral fibres when the grain is allowed to ripen, thereby preventing the best of the fibrous matter from being utilised for the manufacture of pulp; in consequence of this, he goes on to say, the whole substance of the stalk is resolvable into pulp, and cellulose of the finest quality for paper and for all the higher uses for which cotton cellulose is now employed."

In an article appearing in the *American Industries* for February, 1910, an account is given of the above process, and the following table of analyses quoted, as a typical case of the average results obtained, to show the progressive stages of sugar accumulation from the beginning to the close of the period of saccharine development.

TABLE I.

	At time cobs were Removed	One Week after Cobbing.	Two Weeks after Cobbing.	Four Weeks after Cobbing.	Six Weeks after Cobbing
Sp. Gravity ..	1·048	1·050	1·058	1·069	1·0759
Sucrose % ..	6·70	9·70	11·09	13·79	14·66
Reducing Sugar	2·50	1·90	1·47	1·11	1·79
Combined Sugar	9·20	11·60	12·56	14·90	16·45
Solids not Sugar	1·80	1·80	1·44	1·90	1·92
Total solids ..	11·00	13·40	13·90	16·80	18·37
Co. of purity ..	60·9	72·3	79·7	82·4	79·8

In this table it will be seen that the sucrose content of the juice at the time of cobbing was 6.7 per cent., and that six weeks later it had increased to 14.66 per cent., a rise of 118 per cent., whilst at the same time the amount of glucose and solids not sugar remained practically unaltered.

Stewart's process has been investigated on a small scale at the Agricultural Laboratories, Salisbury, this year. The maize used in the test was a white dent variety planted on the 25th January, but the crop unfortunately made a somewhat poor growth on account of the lateness of planting and infestation of stalk borers. The cobs were removed in the milky stage, and only the best stalks were selected for analysis; any portion attacked by borer being carefully discarded.

The results obtained in this trial were as follows:—

TABLE 2.

Number of days after removal of Cobs.	Juice expressed.	Specific gravity of Juice.	Total Solids.	Sucrose.	Glucose.	Solids not Sugar.
	%		%	%	%	%
7	43·8	1·055	13·25	7·41	3·46	2·38
13	47·0	1·060	13·87	8·27	3·32	2·30
23	44·0	1·054	13·30	8·06	2 88	2·36
28	46·0	1·052	12·73	7·23	3·04	2·46
35	46·5	1·057	13·56	8.53	2·30	2·73
53	40·9	1·060	14·29	9·08	2·59	2·62
55	43·9	1·058	13·95	8·01	3·02	2·92
60	45·9	1·061	14·48	9·62	1·98	2·88

It is to be noticed that in no instance did a marked increase in the amount of sucrose present in the juice manifest itself as the length of time after the removal of the cob advanced

In dealing with these figures, however, due account must be taken of the particulars already given regarding the condition of the crop. With a view to finding at the same time the amount of sugar in the juice of uncobbed plants, two tests were made, and the results obtained are given in Table 3.

TABLE 3.

Juice expressed.	Specific gravity of Juice.	Total Solids.	Sucrose.	Glucose.	Solids not Sugar.
%		%	%	%	%
44·6	1·062	14·90	9·56	2·99	2 35
46·4	1·057	13·72	8·61	2·52	2·59

On comparison, it will be seen that the sugar content of the cobbed and the uncobbed plants examined was practically the same; in other words, that the removal of the cob in the milky stage had no material influence upon the sugar content of the stalk.

Dr. Collier, to whom reference has already been made, in reporting on his work upon the sugar content of the maize stalk in 1880 and 1881, gives the analyses of the stalks of several varieties. With one of the varieties, *viz.*, Egyptian sugar corn, the cobs on one part of the plot were removed in the milky stage, and the stalks examined at intervals of one week after the cobs had been plucked. On the other portion of the plot the cobs were allowed to remain. The results of the analyses made by Collier of stalks from the cobbed and uncobbed portions are given in Table 4.

TABLE 4.

Egyptian Sugar Corn.—Analyses made after the cobs had been removed from a portion of the plot. (Collier.)

		Number of Days after removing Cobs from Plants on Portion "B."					
		0	7	14	21	25	28
"B" Cobs removed when in the milky stage.	Amount of Juice %	61 45	60·38	59 61	59·19		51·65
	Sp. Gravity ..	1·043	1·051	1·049	1·058		1·064
	Sucrose, % ..	5 79	7·53	7 68	10·99		10·52
	Glucose, % ..	3·65	3·11	3·13	1·99		3·52
	Solids not sugar % ..	2·22	2·15	2·18	1·61		2·34
	Crystallisable Sucrose %	..	2 27	2·37	7 39		4·66
"A" Cobs not removed.	Amount of Juice, % ..	61·45	57 23	58·38	56·08	53·63	
	Sp. Gravity ..	1·043	1·039	1 062	1 067	1·047	
	Sucrose, % ..	5·79	5·03	11·02	13·20	7·58	
	Glucose, % ..	3·65	2·96	2·40	2·66	2 50	
	Solids not sugar, % ..	2·22	1·53	4 14	2 07	1·05	
	Crystallisable Sucrose %	..	0·54	4·48	8·47	4·03	

The points to be noticed in Collier's results are:—

(1) That the highest amount of cane sugar (13.2 per cent.) was recorded in that portion of the plot from which the cobs had not been removed.

(2) That although the sucrose increased more uniformly in the cobbed portion, the amount of crystallisable sugar is practically the same on the cobbed and uncobbed portions.

(3) That the increase in the amount of crystallisable sugar was not uniform.

Collier in his report mentions that the composition of maize stalk juice appears to vary greatly, even among specimens of the same variety taken at the same time from the same field; he further states that sugar of excellent quality and in paying quantity has been obtained from maize stalks after the seed has been thoroughly ripened, and that by selection, varieties of maize having a more uniform content of sugar may be produced. Although the results obtained this year from the limited number of tests which have been made in Rhodesia do not support Stewart's contention that the removal of the cobs in the milky stage causes a marked increase in the amount of sucrose present in the juice of the stalk, it is intended to carry out further trials on a more extensive scale during the coming season.

The fact that the stalks with which I had to work this year were of rather indifferent growth may have had some influence upon the results obtained, but it is noteworthy that these results are more or less in conformity with those obtained by Collier.

Radium in Australia.—Thirty tons of ore from Olary, South Australia, treated at the Bairnsdale School of Mines, are estimated to yield radium to the value of from £1,800 to £2,500. The Director of the School of Mines declares the Olary radium deposit to be the most extensive known at the present time. He considers that the ore in one block, above the 80 ft. level, contains 162,400 lbs. of uranium oxide and 20.8 grains of radium as bromide, or more than twice the amount of radium bromide that now forms the entire available stock in the world.

South African Zoology.—In connection with the technical evening classes instituted some years ago by the Cape Division School Board, and held at the South African College, a course of lectures was delivered by Dr. J. D. F. Gilchrist, Professor of Zoology at the College, on the subject of "Zoology as applied to South African Agriculture." On account of their manifest practical utility Professor Gilchrist recently acceded to the request that he should expand these lectures and publish them in book form.* The work is intended to constitute a text-

* J. D. F. Gilchrist, M.A., D.Sc., Ph.D., "South African Zoology," Cape Town: T. M. Miller, 1911. Royal 8vo, pp. xi, 323 illus. 10s. 6d. nett.

book for teachers and students in South Africa, and, in harmony with this idea, the author has replaced the European types, usually described in similar works, by the South African types (*e.g.*, the crawfish) prescribed for the first B.Sc. examination in Agriculture by the Cape University. In other respects, too, particular reference is made to the more familiar forms of South African fauna, and, apart from its special function as a text-book, the South African agriculturist will find in the publication much that is of very real and practical interest in regard to the life histories of such farm pests as the locust, phylloxera, codling moth, and various ticks. In a general zoological text-book much must of necessity appertain to the science as a whole, independent of geographical limits, but the author's plan has been, wherever possible, to exemplify phases of his subject requiring illustration from genera and species occurring in South Africa, and thus a specially South African character has been imparted to the book. Definite instances of this are met with in respect of each of the ten main subdivisions of the animal kingdom. Thus, amongst the protozoa the African trypanosomes referred to possess a particular local interest, nor are the species of *Piroplasma* mentioned of any less moment to the dwellers in this land. Amongst the cœlenterata reference will be found to the *Hydra* common in South African vleis, and also to the *Alcyonaria,* whence the red "zee tak" originates. Of the sponges, the South African fresh-water sponge *Ephydatia fluviatilis* var. *capensis* forms a suitable illustration. Then there are the flat worms, of which the liver fluke (*Distomum hepaticum*) is taken as an illustrative type, and its life history is detailed. After these round worms are dealt with, and here again South Africa affords a fitting example in the pest, so common among sheep, *Strongylus contortus*, or wire worm. Other South African strongyles are also referred to in briefer terms. The well-known vinegar eel and the potato eel worm belong to other families of the same class frequent in South Africa. The ordinary earth worm illustrates the next subdivision, which comprises the annelida, a phylum wherein is also included the Cape leech (*Hirudo capensis*) found on the Cape Flats. The next class, arthropods, introduces animals with definite jointed limbs, and here a good deal of attention is given to the Cape crawfish. In addition, numerous other South African crustacea, such as the blue prawn and the fresh-water crab, aid in illustrating the subdivision, which also includes the gardener's wire worm and the centipedes. Numerous insects characteristic of South Africa are mentioned in Class IV of this phylum. Here we find mantidæ and stick insects—such as the *Bacillus stellenboschus*—while South African locusts and grasshoppers, as well as termites, ants, bees and wasps, are given no larger share of attention than circumstances warrant. Incidental reference is made to the *Blastophaga,* successfully introduced into this country by Mr. C. P. Lounsbury, Chief

Entomologist of the Union, and essential to the ripening of the cultivated fig. On the other hand, Mr. Lounsbury has supplied California with a South African chalcid wasp, *Scutellista,* whose agricultural function is the repression of the black scale insect. The next order of arthropods embraces, amongst others, the South African chafer beetles and ladybirds. To the last-named must now be considered to belong the *Vedalia cardinalis,* whose importation by the Cape Government in 1891 was the means of successfully checking the Dorthesia (*Icerya purchasi*), at that time a severe garden pest in and about Cape Town. To butterflies and moths the limitations of a text-book naturally permit of scarcely more than incidental reference, but amongst those referred to, the orange-tree butterfly (*Papilio demoleus*) and the death's-head moth (*Acherontia atropos*) are prominent. The diptera described and illustrated include *Glossina morsitans* and *G. palpalis,* as well as the Natal fruit fly and the bot flies of the horse and ox. The aphidæ are briefly referred to in general terms, special attention being bestowed on *Phylloxera vastatrix*, whose life history is detailed. Some of the scale insects are next dealt with, and reference is made to the recent appearance of *Aspidiotus perniciosus* (San José scale) in the Transvaal Province. The important phylum of arthropods also includes the arachnids, and amongst these the scorpions and spiders. Good illustrations are given of the common South African scorpion (*Opisthophthalmus Karooensis*) and of the great baboon spider (*Ceratogyrus darlingi*). After a short consideration of the sheep-scab mite and the various ticks, the author passes on to the next subdivision—the molluscs. Of these the common garden snail is taken as a type, and the history of its introduction into South Africa recounted. In the next subdivision—echinodermata—the chief South African representatives of the star-fish and sea-urchin classes are referred to, after which there is a further upward movement in the scale of life to the final phylum—that of the vertebrates. This phylum includes fishes, amphibia, birds, reptiles and mammals, and occupies one-third of the book. Here the author traverses in outline the whole range of back-boned animals familiar to South Africans, from "rooi aas" (red bait, *i.e., Polycarpa*) to man. Such common South African types as the sea-snake, dog-fish, silver fish, stock-fish, all appear in turn. Amongst the South African frogs we meet the small globular "rain frog," and amongst the lizards, snakes, and tortoises, those peculiar to this country are all typically represented. From reptiles we pass to birds, where as full an account of the South African representatives of the twelve orders is given as one can expect to find summarised within the limits of eight pages. Last of all, the mammalia are reached. Here some attention is given—after dealing with such characteristically South African types as the "dassie," the hippopotamus, and the giraffe—to the great variety of antelopes in which the country abounds. Of the three South African zebras, one, *Equus quagga,* formerly abundant south of the Vaal, is now extinct: *Equus zebra* is much more scarce than it used to be within recent memory; but *Equus burchelli* is still numerous north of the Orange River. Of the next genus, rhinoceros, one species, *R. simus,* the erstwhile very abundant white rhinoceros, survives in only a few individuals in Zululand. The carnivora of the country are illustrated by the leopard, still fairly common throughout South Africa, the spotted hyæna, the hunting dog, and the African ratel. The European squirrel, quite recently introduced into South Africa, has now become abundant in the suburbs of Cape Town, but South Africa has in addition four species of native squirrels. The concluding pages of the work contain brief references, in every instance illustrated by South African types, to moles, porcupines, hares, bats, lemurs, and apes. The book is well and copiously illustrated, over 200 types being thus represented by text figures.

TRANSACTIONS OF SOCIETIES.

CHEMICAL, METALLURGICAL AND MINING SOCIETY OF SOUTH AFRICA.—Saturday, December 16th: Mr. W. R. Dowling, M.I.M.M., Vice-President, in the chair.—"Notes on absorption of gold by amalgamated copper plates, cast iron retorts, and amalgam trays": Professor G. H. **Stanley** and M. T. **Murray.** The authors had carried out an investigation with the object of ascertaining whether there was any foundation for the belief that considerable amounts of gold are absorbed by the amalgamated plates used in gold reduction plants. The conclusion come to was that gold is not absorbed in sufficient amount to influence percentage recovery, but that a comparatively rich hard surface scale may be formed. In used and discarded retorts it was found that a very valuable quantity of gold was present, which would not be removed by mere scaling or chipping of the interior. Sections cut from a piece of cast iron amalgam tray were found to be rich in gold.

SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS.—Thursday, December 21st: Mr. J. H. Rider, V.P.I.E.E., President, in the chair.—"Radiotelegraphy in modern practice": W. E. D. **Bennett.** The author first described the fundamental principles involved in the operation of radiotelegraphy, and then gave a general description of the Marconi station on the Bluff at Durban, Natal.

SOUTH AFRICAN INSTITUTION OF ENGINEERS.—Saturday, January 13th: Mr. F. H. Davis, President, in the chair.—"Current and Power factor in induction motors". H. J. S. **Heather.** The author presented the results of a series of tests to show that in an induction motor the power factor at constant amperes is unaffected by the speed.—"The combustion of coal": K. **Austin.** The author discussed the economical utilisation of coal with a view to the fullest realisation of its thermal value in all cases. He suggested modification of combustion chambers and of the general arrangement of boiler plants, an exhaustive enquiry into the best methods of effecting such improvements, and the establishment of public coal-testing institutions.

NEW BOOKS.

Knox, Alexander.—*The climate of the continent of Africa.* Cambridge: University Press, 1911. 9 in. × 6½ in. pp. xiv, 552. Maps and diagrams. 21s. nett.

Hall, R. N.—*Rhodesia Museum, Bulawayo. What visitors can see. Ethnological section.* Part I. Bulawayo, 1911. pp. 62. 8½ in. × 5½ in. Illus.

PRELIMINARY LIST OF THE PLANTS OF SOUTHERN RHODESIA.

By Frederick Eyles, F.L.S., M.L.C.

About four years ago I promised to send the Rhodesia Scientific Association a preliminary catalogue of plants recorded from Southern Rhodesia. Owing to circumstances beyond my control, that promise has not been fulfilled, and the Council of that society has probably long ago given me up as hopeless. I now have pleasure in presenting a provisional list of Rhodesian plants, but my pleasure is much diminished by the knowledge that my work is very imperfect, and falls far short of the ideal I had set.

The catalogue is a bare list of names, from which are omitted the numerous synonyms so necessary for the ready identification of species by means of such works of reference as are usually accessible to South Africans. Neither have I been able to include those vernacular names registered, nor the still more important records of localities, altitudes, and dates of flowering and collection, and the names and herbarium numbers of collectors. All this material is in my hands, but I have not yet found time to get the complete record arranged for printing. Unfortunately, the catalogue, even in its present form, is not quite up to date, as valuable lists of takings by Mr. Monro, in the Victoria District and of Mr. Swynnerton in Melsetter and Chirinda Forest, have not yet been incorporated.

The catalogue of Phanerogams has been arranged on Engler's system, my guide being the "Genera Siphonogamarum" of Drs. De Dalla Torre and Harms, while the Ferns and their allies have been placed in the order given by Sim in his "Ferns of South Africa."

So far as I have been able to get access to them, I have incorporated the collections of Kirk, Holub, Baines, Meller, Oates, Rand, Galpin, Flanagan, Cecil, Allen, Monro, Swynnerton, Engler, Eyles, Marloth, Holland, Gibbs, Gardner, Jeffreys, Kolbe, Mundy and Chubb and other less considerable contributors. Doubtless, many additional identifications of Rhodesian plants have been made, particularly by German botanists, but these I have not had access to, and I can only hope that this list, small and imperfect as it is, may be made the foundation of a more comprehensive and detailed work.

The present catalogue comprises representatives of 136 families, 687 genera, and 1,700 to 1,800 species; to which, as I have said, considerable additions can be made immediately from material in my possession. Further, if I could enlist the sympathy and help of those members of the South African Association for the Advancement of Science who themselves have made collections in Southern Rhodesia, or who know of collections made by others; and if they would send me their lists of identifications, with dates, habitats and other particulars, it would then be possible for me to get out a comparatively complete catalogue of our plants as recorded to date.

The plants actually taken by myself are not very numerous, so that my personal knowledge of the Rhodesian flora is limited. I have been fortunate, however, in being able to collect in a variety of widely separated districts—*viz.*, Victoria Falls, Bulawayo, Matopos, Sebakwe, Salisbury and Mazoe. For the identification of specimens I am chiefly indebted to the British Museum and the late Dr. Bolus, but I also received help from the late Prof. MacOwan and Dr. Marloth.

For invaluable assistance in compiling the catalogue I must specially place on record my indebtedness to Dr. Bolus, to whom nothing was a trouble, and who spared no pains to encourage an obscure and humble follower in his footsteps.

Others to whom I wish to express thanks for assistance and advice, particularly in the matter of sending me copies of their Rhodesian identifications, are Drs. Rand and Marloth; Mr. E. F. Allen, late of the Agricultural Department; Mr. C. F. H. Monro, M.A., of Victoria; Mr. Mervyn Jeffreys, of Bulawayo; Mr. C. F. M. Swynnerton, of Melsetter; Mr. E. E. Galpin, F.L.S.; Miss Gibbs, F.L.S.; Rev. Father Gardner, of Bulawayo; Mr. E. C. Chubb, F.Z.S.; and Mr. H. G. Mundy, of Salisbury.

At present I make no attempt to analyse the Rhodesian flora, nor to compare it with the floras of other South African regions. This may be the subject of a later paper when more complete material will be available; or, better still, some more able hand may perhaps undertake that work, guided by a deeper and wider knowledge of the subject than the present writer.

In the following list the Ferns and their allies, as already stated, follow the arrangement given in "Ferns of South Africa," by T. R. Sim; while the few other Cryptogams recorded are placed in the order shown in Strasburger's "Text-Book of Botany."

THALLOPHYTA.

NOSTOCACEÆ.

Nostoc commune Vaucher.

CHARACEÆ

Chara capensis E. Mey.
Nitella hyalina Ag.

FUNGI.

Cronartium Bresadoleanum (?) P. Henn., var. *eucleæ* P.H.
Polystictus sanguineus Meyer.
Hymenochæte rubiginosa Sev.

LICHENES.

Leptogium sp.
Parmelia sp.
Usnea barbata Ach.

BRYOPHYTA.

RICCIACEÆ.

Riccia fluitans L.

MARCHANTIACEÆ.

Fimbriaria marginata Nees.
Marchantia polymorpha L.
Plagiochasma sp.

MUSCINEÆ.

MUSCI.

Orthotrichum sp.
Racopilum sp.
Amblystegium varium Lindb.
Octodiceras julianum Brid.
Hypnum sp.
Ulota crispa Br. and Schimp.
Bartramia sp.

PTERIDOPHYTA.

FILICES AND ALLIES (Sim's arrangement).

1. *Gleichenia dichotoma* Willd.
   polypodiodes, Smith.
4. *Cyathea Dregei* Kunze.
7. *Davallia Hollandii* Sim.
8. *Cystopteris fragilis* Bernh.
10. *Adiantum æthiopicum* L.
    capillus veneris L.
    caudatum L.
    lunulatum Burm.
    Oatesii Baker.
12. *Hypolepis Schimperi* Sim.
13. *Cheilanthes Bolusii* Baker.
    farinosa Kaulf.
    hirta Swartz.
    multifida Swartz
14. *Pellæa Burkeana*, Baker.
    calomelanos Link.
    consobrina Hook.
    Doniana Hook.
    geraniæfolia Fee.
    hastata Link.
    hastata Link, var. *glauca*.
    pectiniformis Baker.

15. *Pteris aquilina* L.
atrovirens Willd.
cretica L.
flabellata Thunb.
longifolia L.
quadriaurita Retz.
16. *Lomaria attenuata* Willd.
Boryana Willd.
punctulata Kze.
18. *Asplenium adiantum-nigrum* L.
anisophyllum Kze.
aspidiodes Schl.
circutarium Sw.
Dregeanum Kze.
erectum Bory.
erectum Bory., var. *lunulatum* Sim.
erectum Bory., var. *erectum* Sim.
erectum Bory., var. *lobatum* Sim.
filix-fœmina Bernh.
furcatum Thunb.
furcatum Thunb., var. *tripinnatum*.
gemmiferum Schr.
gemmiferum Schr., var. *flexuosum*.
monanthemum L.
protensum Schrad. var.
rutæfolium Kunze.
Sandersoni Hook.
Schimperi A. Br.
trichomanes L.
varians Hk. and Gr.
Asplenium (probably new sp. Sim).
19. *Actiniopteris radiata* Link.
20. *Didymochlæna lunulata* Desv.
21. *Aspidium aculeatum* Swartz., var. *pungens*.
22. *Nephrodium albo-punctatum* Desv.
athamanticum Hook.
Bergianum Baker.
catopteron Hook.
circutarium Baker.
filix-mas Rich., var. *elongatum*.
inæquale Hook.
mauritianum Fee.
molle Desv.
molle Desv., var. *violaceum* (Link), Mett.
Thelypteris Desv.
unitum R. Br.
23. *Nephrolepis cordifolia* Presl.
exaltata Schott.
25. *Polypodium africanum* Mett.
incanum Swartz.

irioides Lam.
normale Don.
lanceolatum L.
obtusilobum Desv.
phymatodes L.
proliferum Presl.
unitum Hook.

26. *Nothochlæna Buchanni* Baker.
inæqualis Kze.

27. *Gymnogramme argentea*, var. *aurea*, Mett
cordata Schlecht.
cordata Schlecht, var. *namaquensis* P. and R.
lanceolata Hook.
leptophylla Desv.

30. *Acrostichum latifolium* Swartz.

30B. *Platycerium alcicorne* Desv.

31. *Osmunda regalis* L.

34. *Ancimia anthriscifolia* Schrad.

35. *Mohria caffrorum* Desv.

35B. *Lygodium Brycei* Baker.
Kerstenii Kuhn.

36. *Marattia fraxinea* Smith.

37. *Ophioglossum reticulatum* L.
vulgatum L.

38. *Equisetum ramosissimum* Desf.

39. *Lycopodium carolinianum* L.
verticillatum L.

40. *Psilotum triquetrum* Swartz.

41. *Selaginella imbricata* Spring.
Kraussiana A. Braun.
rupestris Spring.
Selaginella sp.

44. *Marsilia biloba* Willd.
capensis A. Br.

PHANEROGAMS.

Family 6. PINACEÆ.

19. *Callitris (Widdringtonia) Whytei*, Rendle.

11. POTAMOGETONACEÆ.

4. *Potamogeton fluitans* Roth.
natans L.
pusillum L.

13. APONOGETONACEÆ.

1. *Aponogeton* sp.

15. ALISMACEÆ.

11. *Burnatia enneandra* Micheli.

17. HYDROCHARITACEÆ.

2. *Hydrilla verticillata* Royle.
6. *Blyxa* sp.
11. *Ottelia paucifolia* A. Rich.
 vesiculata Ridl.

19. GRAMINEÆ.

2. *Zea mays* L.
9. *Imperata arundinacea* Cyr.
12. *Erianthus teretifolius* Stapf.
13. *Pollinia villosa* Spreng.
19. *Ischæmum fasciculatum* Brongn.
27. *Rottboellia compressa* ?
 compressa L. f., var. *fasiculata* Hack.
31. *Trachypogon polymorphus* Hack.
32. *Elionurus argenteus* Nees.
34. *Andropogon amplectens* Nees.
 contortus L.
 cymbarius L.
 eucomus Nees.
 filipendulus Hochst.
 Gardneri Hack.
 gayances ? Kunth.
 hirtus L.
 hydrogyrum ?
 lepidus, var. *tamba* ?
 monticola Schult., var. *Trinii* Hook.
 nardus, var. *validus* Stapf.
 pertusus Willd.
 rufus Kunth.
 Ruprechti Hack.
 Schoenanthus ?
 Schimperi Hochst.
 serratus Thunb., var. *versicolor* Hack.
 sorghum Brot.
 squarrosus L. f.
 Andropogon spp.
36. *Themeda triandra* Forsk., var. *imberbis* Hack.
43. *Tragus racemosus* All.
48. *Perotis latifolia* Ait.
53. *Arundinella Ecklonii* Nees.
61. *Paspalum scrobiculatum* L.
66. *Panicum brizanthum* Hochst.
 bulawayense Hack.
 commutatum Nees.
 helopus Trin.
 Isachne Roth and Roem.
 lævifolium Hack.
 maximum Jacq.
 maximum Jacq., var. *trichoglume.*

minus Stapf., var.
nigropedatum Munro.
sanguinale L.
sanguinale L., var. *ciliata*.
serratum Spreng.
stagninum Koenig.
trichopus Hochst.
Panicum sp.
68. *Tricholæna glabra* Stapf.
rosea Nees.
69. *Oplismenus africanus* P. Beauv.
Oplismenus sp.
71. *Setaria aurea* A. Br.
flabellata Stapf.
Gerrardii Stapf.
imberbis Roem. and Schult.
nigrirostris Dur. and Sch.
verticillata (L.) Beauv.
75. *Pennisetum Benthamii* Steud.
cenchroides Rich.
macrourum Trin.
typhoideum Rich.
108. *Aristida æquiglumis* Hack.
angustata Stapf.
bipartita Trin. and Rupr.
ciliata Desf.
congesta Roem. and Schl.
sieberiana Trin., var. *stipitata* Stapf.
stipoides Lam.
Aristida sp.
130. *Sporobolus festivus* Hochst. var. *stuppeus* Stapf.
festivus Hochst., var. *fibrosus*.
indicus R. Br.
indicus R. Br., var. *laxus* Sapf.
Sporobolus sp.
177. *Tristachya biseriata* Stapf.
178. *Trichopteryx simplex* Hack.
Trichopteryx sp.
181. *Microchloa caffra* Nees.
182. *Cynodon dactylon* Pers.
incompletus Nees.
186. *Ctenium* sp.
188. *Chloris gayana* Kunth.
petræa Thunb.
pycnothrix Trin.
virgata Swartz.
198. *Tripogon abyssinicus* Nees.
204. *Eleusine coracana* Gaertn.
indica Gaertn.
205. *Dactyloctenium ægyptiacum* Willd.

209B. *Crossotropis grandiglumis* Rendle.
212. *Schmidtia pappophoroides* Steud.
233. *Phragmites communis* Trin.
237A. *Pogonarthria falcata* Rendle.
241. *Eragrostis Atherstonei* Stapf.
barbinodis Hack.
brizoides Nees.
chalcantha Trin.
Chapelieri (Kunth) Nees.
curvula Nees.
Gardneri Hack.
gummiflua Nees.
Lappula Nees., var. *divaricata* Stapf., *forma macra* Hack.
namaquensis Nees., var. *robusta*.
patentipilosa Hack.
sclerantha Nees., var. *retinorrhœa* Steud.
superba Peyr.
tenella Stapf., var. *plumosa*.
uniglumis Hack.
viscosa Trin.
Eragrostis spp.
285. *Festuca* sp.
?. *Stereochlæna Gardneri* Hack.

20. CYPERACEÆ.

3. *Ascolepis capensis* (Kunth.) Ridley.
protea Welw.
8. *Cyperus angulatus* Nees.
aristatus Rottb.
betschuanus Boeck.
compactus Lam.
compactus Lam., var. *flavissimus* C. B. Cl.
denudatus L. f.
esculentus L.
globosus Boeck., var. *nilagirica* C. B. Cl.
Haspan L.
Haspan L., var. *americana* Boeck.
margaritaceus Vahl.
margaritaceus Vahl., var. *pseudonivea* C. B. Cl.
Mundtii Nees.
tenax Boeck.
textilis Thunb.
Zollingeri Steud.
Cyperus spp.
10. *Courtoisia cyperoides* Nees.
11. *Kyllinga alba* Nees.
Kyllinga sp.
16. *Fuirena glomerata* Lam.
hirta Vahl.

Oedipus C. B. Cl.
stricta Steud.
subdigitata C. B. Cl.
Fuirena spp.
17. *Scirpus fluitans* L.
paludicola Kunth.
supinus L.
18. *Heleocharis capitata* Boeck.
Kirkii.
20. *Fimbristylis cardiocarpa*, var. *Holubii* C. B. Cl.
exilis Roem. and Sch.
Fimbristylis spp.
54. *Scleria* sp.

21. PALMÆ.

1. *Phœnix reclinata* Jacq.
26. *Hyphaene crinita* Gaertn.
ventricosa Kirk.

23. ARACEÆ.

40. *Amorphophallus mossambicensis* Klotzsch.
65. *Zantedeschia melanoleuca* var. *tropicalis* N. E. Br.

29. XYRIDACEÆ.

1. *Xyris capensis* Thunb.
dispar N. E. Br.
multicaulis N. E. Br.
obscura N. E. Br.
umbilonis Nilss.
Xyris spp.

30. ERICAULACEÆ.

1. *Eriocaulon amphibium* Rendle.
bifistulosum Van Heurck.
lacteum Rendle.
matopense Rendle.
submersum Welw.
sublatum N. E. Br.
3. *Pæpalanthus Wahlbergii* Korn.

33. COMMELINACEÆ.

4. *Commelina Bainesii* C. B. Cl.
benghalensis L.
Cecilæ C. B. Cl.
Forskalei Vahl.
Holubii C. B. Cl.
krebsiana Kunth.
krebsiana Kunth., var. *villosior* C. B. Cl.
Livingstoni C. B. Cl.
nudiflora L.
spectabilis C. B. Cl.
Commelina spp.

7. *Aneilema æquinoctiale* Kunth.
    Dregeana Kunth.
    Johnstoni K. Schum.
    Nicholsoni C. B. Cl.
    sinicum Lindl.
    sinicum Lindl., var. *longifolia* C. B. Cl.
Aneilema sp.
12. *Cyanotis fœcunda* Hassk.
    nodiflora Kunth.
16. *Floscopa glomerata* Hassk.
Floscopa sp.

36. JUNCACEÆ.

7. *Juncus Fontanesii* (Laharpe) J. Gay.

38. LILIACEÆ.

22. *Gloriosa superba* L.
    virescens Lindl.
28. *Androcymbium subulatum* Baker.
32. *Ornithoglossum glaucum* Salisb.
Ornithoglossum glaucum Salisb., var. *grandiflorum* Baker.
48. *Anthericum anceps* Baker.
    elongatum Willd.
    matabelense Baker.
    Oatesii Baker.
    recurvifolium Baker.
Anthericum spp.
49. *Chlorophytum elatum* R. Br., var. *Burchelli* Baker.
Chlorophytum spp.
69. *Schizobasis angolensis* Baker.
70. *Bowiea volubilis* Harv.
71. *Eriospermum Cecili* Baker.
Eriospermum spp.
83. *Kniphofia* sp.
85. *Aloe excelsa* Berger.
Aloe sp.
106. *Tulbaghia alliacea* L. f.
    campanulata N. E. Br.
Tulbaghia spp.
138. *Albuca caudata* Jacq.
    Tayloriana Rendle.
    Wakefieldii Baker.
Albuca spp.
139. *Urginea altissima* Baker.
    sanguinea Schinz.
Urginea spp.
143. *Dipcadi anthericoides* Engl.
    viride Moench.
Dipcadi sp.

145. *Scilla ciliata* Baker.
lanceæfolia Baker.
maesta Baker.
rigidifolia Kunth.
Scilla sp.
147. *Eucomis undulata* Ait.
zambesiaca Baker.
Eucomis spp.
149. *Drimiopsis maculata* Lindl.
168. *Dracæna* sp.
169. *Sansevieria cylindrica* Bojer.
senegalensis ?
Sansevieria sp.
172. *Asparagus africanus* Lam.
laricinus Burch.
pilosus Baker.
plumosus Baker.
racemosus Willd.
Asparagus spp.
210. *Smilax Kraussiana* Meisn.

40. AMARYLLIDACEÆ.

2. *Hæmanthus Cecilae* Baker.
multiflorus Martyn.
zambesiacus Baker.
3. *Buphane disticha* Herbert.
12. *Brunsvigia* spp.
24. *Crinum Harmsii* Baker.
zeylanicum L.
Crinum spp.
26. *Cyrtanthus angustifolius* Ait.
37. *Pancratium* sp.
43. *Hippeastrum equestre* Herb.
65. *Hypoxis angustifolia* Lam.
rigidula Baker.
rigidula var. *pilosissima* Baker.
Rooperii Moore.
villosa L. f.
Hypoxis spp.
66. *Walleria nutans* Kirk.
Walleria sp.

41. VELLOZIACEÆ.

1. *Vellozia equisetoides* Baker.
humilis Baker.
retinervis ?
Vellozia spp.
2. *Barbacenia* sp.

42. TACCACEÆ.

1. *Tacca pinnatifida* Forsk.

43. DIOSCOREACEÆ.

3. *Dioscorea beccariana* Mart.
   dumetorum Pax.
   Schimperiana var. *vestita* Pax.
   Dioscorea sp.

44. IRIDACEÆ.

7. *Moræa* spp.
14. *Ferraria Randii* Rendle.
43. *Hesperantha matopensis* Gibbs.
52. *Babiana Bainesii* Baker.
53. *Gladiolus atropurpureus* Baker.
    brevicauliis Baker.
    dracocephalus Hook f.
    Melleri Baker.
    Oatesii Rolfe.
    primulinus Baker.
    quartinianus A. Rich.
    Gladiolus spp.
54. *Antholyza zambesiaca* Baker.
56. *Lapeyrousia caudata* Schinz.
    cyanescens Baker.
    grandiflora Baker.
    porphyrosiphon Baker.
    rhodesiana N. E. Br.
    Sandersoni Baker.
    Welwitschii Baker.
    Lapeyrousia spp.

45. MUSACEÆ.

1. *Musa ensete* Gmelin.

46. ZINGIBERACEÆ.

6. *Kæmpferia Carsoni* Baker.
   Kirkii K. Schum., var. *eliator* Stapf.
21. *Amomum* spp.

47. CANNACEÆ.

1. *Canna indica* L.

49. BURMANNIACEÆ.

7. *Burmannia bicolor* var. *africana* Ridley.

50. ORCHIDACEÆ.

20. *Holothirx grandiflora* Rchb. f.
    Randii Rendle.
34. *Habenaria antennifera* ?
    Holubii Rolfe.
    malacophylla Reichenb. f.
    pedicallaris Rchb. f.
    Habenaria spp.
40. *Brachycorythis hispidula* ?

42. *Satyrium Buchanii* Schl.
    macrophyllum Lindl.
43. *Schizochilus Cecili* Rolfe.
46. *Disa equestris* Reichb.
180. *Ansellia africana* Lindl.
    humilis Bull.
243. *Calanthe natalensis* Rchb. f.
    Sanderiana Rolfe.
    Calanthe sp.
259. *Lissochilus arenarius* Lindl.
    Eylesii Rendle.
    Livingstonianus Rchb. f.
    microceras Rchb. f.
    milanjianus Rendle.
    Oatesii Rolfe.
    Wakefieldii Rchb. f. and S. Moore.
260. *Eulophia clitellifer* Bolus.
    Dregeana Lindl.
    Krebsii Bolus.
    saccatus ?
    speciosa Bolus.
    undulata ?
    Welwitschii Rolfe.
    Eulophia spp.
263. *Pteroglossaspis* ?
434. *Saccolabium* ?
440. *Angræcum* sp.
449. *Mystacidium* sp.

53. PIPERACEÆ.

4. *Piper nigrum* L. var.
8. *Peperomia brachytrichoides* Engl.
    Peperomia sp.

56. SALICACEÆ.

2. *Salix capensis* Thunb.
    ramiflora R. v. Seem.
    Safsaf ?
    Salix sp.

57. MYRICACEÆ.

1. *Myrica æthopica* L.

63. ULMACEÆ.

5. *Celtis* spp.

64. MORACEÆ.

54. *Ficus capensis* Thunb.
    lutea Vahl.
    maschonæ Warb.
    matabelæ Warb.
    natalensis Hochst.

Rehmannii Warb.
rhodesiaca Warb.
salicifolia Vahl., var. *australis* Warb.
Sonderi Miq.
Sonderi Miq., var. *villosa* Warb.
Victoriæ Warb.
Ficus spp.

66. PROTEACEÆ.

19. *Faurea saligna* Harv.
speciosa Welw.
speciosa Welw., var. *lanuginosa* Hiern.
usambarensis Engl.
20. *Protea abyssinica* Willd.
grandiflora L.
maschonica Engl.
mellifera Thunb.
Protea spp.

67. LORANTHACEÆ.

5. *Loranthus acaciæ* Zucci.
Cecilæ N. E. Br.
curviflorus Benth.
Dregei E. and Z.
Dregei E. and Z., forma *subcuneifolia* Engl
Kraussianus Meissn.
namaquensis Harv.
virescens N. E. Br.
zambesicus Gibbs.
Loranthus spp.
24. *Viscum dichotomum* Don.
matabelense Engl.
tuberculatum A. Rich.
verrucosum Harv.
Viscum spp.

69. SANTALACEÆ.

9. *Colpoon compressum* Berg.
23. *Thesium brevibarbatum* Pilger.
multiramulosum Pilger.
rhodesiacum Pilger.
Thesium spp.

72. OLACACEÆ.

3. *Olax dissitiflora* Oliv.
8. *Ximenia americana* L.
caffra Sond.
Ximenia spp.

76. HYDNORACEÆ.

1. *Hydnora africana* ?

77. POLYGONACEÆ.

18. *Polygonum aviculare* L.
barbatum L.
herniarioides Del.
tomentosum Willd.
Polygonum spp.
21. *Oxygonum Dregei* Meissn.
pubescens C. H. Wright.
Zeyheri Sond.
Oxygonum spp.

78. CHENOPODIACEÆ.

10. *Chenopodium* sp.

79. AMARANTACEÆ.

4. *Celosia trigyna* L.
Celosia sp.
17. *Sericocoma angustifolia* Hook f.
24. *Cyathula cylindrica* Moq.
29. *Aerva lanata* Moq. ?
leucura Moq.
Aerva sp.
40. *Achyranthes argentea* Lam.
aspera L.
47. *Alternanthera sessilis* R. Br.

80. NYCTAGINACEÆ.

7. *Boerhaavia dichotoma* Vahl.
grandiflora A. Rich.
pentandra Burch.
plumbaginea ?

83. PHYTOLACCACEÆ.

13. *Limeum fenestrata* Fenzl.
viscosum Fenzl.
17. *Phytolacca abyssinica* Hoffm.
Phytolacca sp.
19. *Gieskia pharnaceoides* L.
Gieskia spp.

84. AIZOACEÆ.

1. *Mollugo hirta* Thunb. var. *virens* Hiern.
2. *Glinus* sp.
3. *Pharnaceum Zeyheri* Sond.
Pharnaceum sp.
7. *Orygia decumbens* Forsk.
19. *Mesembryanthemum* sp.

85. PORTULACACEÆ.

1. *Talinum caffrum* E. and Z.

87. CARYOPHYLLACEÆ.

27. *Polycarpæa corymbosa* Lam.
39. *Pollichia campestris* Ait.
41. *Corrigiola litoralis* L.
62. *Silene Burchelli* Otth.

88. NYMPHAEACEÆ.

6. *Nymphæa lotus* L.
stellata Willd.

91. RANUNCULACEÆ.

22. *Clematis Kirkii* Oliv.
orientalis L.
Stanleyi Hook.
Thunbergii Steud.
vioma ?
Clematis spp.
26. *Ranunculus pinnatus* Poir.

94. MENISPERMACEÆ.

8. *Cissampelos Pareira* L.
Pareira L. var. *mucronata* Engl.
11. *Tiliacora funifera* Oliv.

98. ANONACEÆ.

27. *Popowia obovata* Engl. and Diels.
52. *Hexalobus senegalensis* A. DC.
60. *Artabotrys brachypetala* Benth.
65. *Anona senegalensis* Pers.
senegalensis Pers. var. *rhodesiaca* Engl. and Diels.

102. LAURACEÆ.

44. *Cassytha capensis* Meisn.

103. HERNANDIACEÆ.

2. *Gyrocarpus americanus* Jacq.

105. CRUCIFERÆ.

13. *Heliophila* sp.
87. *Brassica* sp.
103. *Nasturtium fluviatile* E. Mey.

107. CAPPARIDACEÆ.

1. *Cleome hirta* Oliv.
maculata Szyszyl.
monophylla L.
6. *Pedicellaria pentaphylla* Schrank.
20. *Capparis tomentosa* Lam.
Capparis sp.

28. *Cadaba natalensis* Sond.
31. *Maerua caffra* (Bernh.) Pax.
    maschonica Gilg.
    nervosa Oliv. var. *flagellaris* Oliv.
    Maerua spp.

112. DROSERACEÆ.

4. *Drosera indica* L.
    ramentacea Burch.
    Drosera sp.

113. PODOSTEMONACEÆ.

2. *Tristicha alternifolia* Tul.
    trifaria Tul.
13. *Dicræa tenax* C. H. Wright.
21. *Sphærothylax* sp.

115. CRASSULACEÆ.

6. *Kalanchoe paniculata* Harv.
    rotundifolia Haw.
    glandulosa Hochst., var. *rhodesica* Baker f.
    Kalanchoe spp.
8. *Crassula campestris* E. and Z.
    Crassula spp.

117. SAXIFRAGACEÆ.

25. *Vahlia capensis* Thunb.
    capensis Thunb., var. *linearis* E. Mey.

118. PITTOSPORACEÆ.

1. *Pittosporum viridiflorum* Sims.

121. MYROTHAMNACEÆ.

1. *Myrothamnus flabellifolia* Welw.

126. ROSACEÆ.

26. *Photinia* sp.
36. *Rubus rigidus* Smith.
57. *Alchemilla* sp.
70. *Cliffortia linearifolia* E. and Z.
87. *Parinarium capense* Harv.
    curatellæfolium Pl.
    mobola Oliv.

127. CONNARACEÆ.

6. *Byrsocarpus coccineus* Schum. and Thonn., var. *parvifolius* Pl.
9. *Rourea* sp.

128. LEGUMINOSÆ.

9. *Albizzia amara* Boivin.
    Antunesiana Harms.
    fastigiata E. Mey.

Harveyi Tourn.
Albizzia spp.
12. *Acacia abyssinica* ?
albida Del.
caffra Willd.
Farnesiana Willd.
giraffæ Burch.
horrida Willd.
mimosoides L.
nigrescens Oliv.
nigrescens DC., var. *pallida* Oliv.
Rehmanniana Schinz.
Seyal Delile.
Seyal Delile, var. *multijuga* Schweinf.
suma Kurz.
Welwitschii Oliv.
xanthophlæa Benth.
Acacia spp.
15. *Mimosa asperata* L.
18. *Dichrostachys nutans* Benth.
Dichrostachys spp.
23. *Tetrapleura* sp.
24. *Amblygonocarpus Schweinfurthii* Harms.
29. *Piptadenia* sp.
33. *Elephantorrhiza Burchelli* Benth.
Burkei Benth.
rubescens Gibbs.
37. *Erythrophloeum pubistamineum* Henn.
40. *Burkea africana* Hook.
Burkea sp.
56. *Copaifera coleosperma* Benth.
mopane Kirk.
70. *Brachystegia appendiculata* Benth.
globiflora Baker.
Goetzei Harms.
Randii Baker.
spiciformis Benth.
tamarindoides Welw.
Brachystegia spp.
72. *Schotia brachypetala* Sond.
Schotia spp.
73. *Baikiæa plurijuga* Harms.
Baikiæa sp.
74. *Tamarindus indica* L.
75. *Afzelia cuanzensis* Welw.
82. *Berlinia Eminii* Taub.
94. *Bauhinia articulata* DC.
fassoglensis Kotschy.
Galpini N. E. Br.
Petersiana Bolle.

Bauhinia spp.
102. *Cassia abbreviata* Oliv.
absus L.
arachoides Burch.
didymobotrya Fres.
fistula L.
grandiflora ?
granitica Baker f.
mimosoides L.
occidentalis L.
Petersiana Bolle.
tettensis Bolle.
Cassia spp.
110. *Gleditschia africana* Welw.
119. *Pterolobium lacerans* R. Br.
123. *Hoffmannseggia* sp.
127. *Peltophorum africanum* Sond.
140. *Swartzia madagascariensis* Desv.
Swartzia sp.
173A. *Bolusanthus speciosus* Harms.
Bolusanthus spp.
223. *Lotononis Leobordea* Benth.
224. *Listia heterophylla* E. Mey.
225. *Rothia hirsuta* Baker.
230. *Dichilus lebeckioides* DC.
235. *Crotalaria anthyllopsis* Welw.
brevidens Benth.
Burkeana Benth.
capensis Jacq.
cephalotes Steud.
flavicarinata Baker f.
intermedia Kotschy.
Kirkii Baker ?
laburnifolia L.
nubica Benth.
pisicarpa Welw.
podocarpa DC.
recta Steud.
spartioides DC.
striata DC.
Crotalaria spp.
239. *Argyrolobium* spp.
268. *Indigofera adenoides* Baker f.
arrecta Hochst.
Cecili N. E. Br.
cryptantha Benth.
dalcoides Benth.
diphylla Vent.
filipes Benth.
goniodes Hochst.

heterotricha DC.
heterotricha DC., var. *rhodesiana* Baker f.
hilaris E. and Z.
hirsuta L.
inyangana N. E. Br.
pentaphylla L.
Schimperi Jaub and Spach. (forma)
secundiflora Poir.
senegalensis Lam.
sericea Benth. ex Baker, forma *australis*, E. G. Baker.
Indigofera spp.
284. *Tephrosia appolinea* DC.
Forbesii Baker ?
lupinifolia DC.
lurida Sond.
radicans Welw.
Tephrosia spp.
285. *Mundulea suberosa* Benth.
286. *Millettia caffra* Meisn.
312. *Microcharis* sp.
313. *Sesbania cinerascens* Welw.
pubescens DC.
punctata DC.
tetraptera Hochst.
Sesbania spp.
322. *Lessertia pauciflora* Harv.
stipulata E. G. Baker.
Lessertia sp.
332. *Astragalus Burkeanus* Benth.
358. *Ormocarpum trichocarpa* Taubert.
Ormocarpum sp.
359. *Aeschynomene cristata* Vatke.
mimosifolia Vatke.
nyassana Taub.
oligantha Welw.
Aeschynomene spp.
362. *Smithia* sp. ?
368. *Stylosanthes erecta* P. Beauv.
369. *Arachis hypogea* L.
370. *Zornia diphylla* Pers.
tetraphylla Michx.
373. *Desmodium paleaceum* Guill. and Perr.
Scalpe DC.
Desmodium sp.
374. *Pseudarthria Hookeri* Wight. and Arn.
376. *Alysicarpus rugosus* DC.
387. *Dalbergia Dekindtiana* Harms.
394. *Pterocarpus erinaceus* Poir.
melliferus Welw.
sericeus Benth.

Pterocarpus spp.
400. *Lonchocarpus capassa* Rolfe.
404. *Derris violacea* (Klotzsch) Harms.
422. *Abrus precatorius* L.
Abrus sp.
427. *Dumasia villosa* DC.
430. *Glycine javanica* L.
436. *Erythrina tomentosa* R. Br.
Zeyheri Harv.
443. *Mucuna coriacea* Baker.
448. *Galactia* sp.
457. *Canavalia ensiformis* DC.
463. *Rhynchosia adenodes* E. and Z.
antennulifera Baker.
caribæa DC.
congensis Baker.
minima DC.
monophylla Schlechtdl.
orthodanum Benth.
puberula Harv.
resinosa Hochst.
Rhynchosia spp.
464. *Eriosema cajanoides* Hook f.
Engleri Harms.
insigne O. Hoffm. ?
oblongum Benth.
polystachyum Baker.
speciosum Welw.
Eriosema spp.
465. *Flemingia rhodocarpa* Baker.
467. *Phaseolus lunatus* L.
Phaseolus sp.
469. *Voandzeia subterranea* Thou.
471. *Vigna Buchneri* Harms.
cærulea Baker.
luteola Benth.
marginata Benth.
nuda N. E. Br.
triloba Walp.
vexillata Benth.
Vigna spp.
473. *Sphenostylis marginata* E. Mey.
476. *Dolichos euryphyllus* Harms, forma *lobata*.
gibbosus Thunb.
Lablab L.
stipulosus Welw., var. *Randii* Baker f.
tricostatus Baker f.
Dolichos spp.
477. *Adenodolichos* ?

129. GERANIACEÆ.

2. *Monsonia biflora* DC.
   Burkeana Planch.
   ovata Cav.
   Monsonia spp.
5. *Pelargonium* sp.

130. OXALIDACEÆ.

2. *Oxalis corniculata* L., var. *stricta*.
   Oxalis spp.

132. LINACEÆ.

3. *Linum Thunbergii* E. and Z.

135. ZYGOPHYLLACEÆ.

8. *Zygophyllum simplex* L.
21. *Tribulus terrestris* L.

137. RUTACEÆ.

5. *Xanthoxylon* spp.
29. *Thamnosma africanum* Engl.
   africanum Engl, var. *rhodesicum*.
115. *Citrus medica* L., var. *limonium* Risso.

138. SIMARUBACEÆ.

23. *Kirkia acuminata* Oliv.

139. BURSERACEÆ.

16. *Commiphora acutidens* Engl.
   Commiphora spp.

140. MELIACEÆ.

17. *Turræa Eylesii* Baker f.
   nilotica Kotschy and Peyr.
   obtusifolia Hochst.
   obtusifolia Hochst., var. *matopensis* Baker f.
   Randii Baker f.
   Turræa spp.
39. *Ekebergia arborea* Baker f.
41. *Trichilia emetica* Vahl.

141. MALPIGHIACEÆ.

19. *Sphedamnocarpus galphiniæfolius* Szylszyl.
   pruriens Planch.
   pulcherimus Gilg.
   Sphedamnocarpus spp.
37. *Tricomaria macrocarpa* ?

145. POLYGALACEÆ.

1. *Polygala abyssinica* Fresn.
   africana Chod.
   arenaria Willd.
   capillaris E. Mey.
   erioptera DC.
   latipetala N. E. Br.
   Livingstoniana Chod.
   persicariæfolia DC.
   Petitiana Rich.
   rarifolia DC.
   rigens A. DC.
   triflora L.
   virgata Thunb.
   Polygala spp.
3. *Securidaca longipedunculata* Fresn.
   longipedunculata Fresn., var. *parvifolia* Oliv.

146. DICHAPETALACEÆ.

1. *Dichapetalum cymosa* Hook.

147. EUPHORBIACEÆ.

10. *Pseudolacnnostylis maprouneæfolia* Pax.
    Pseudolachnostylis spp.
14. *Phyllanthus floribundus* Mull. Arg.
    longifolius Sond. (forma).
    Niruri L.
    reticulatus Poir.
    Phyllanthus spp.
42. *Antidesma venosum* Tul.
44. *Uapaca Kirkiana* Mull. Arg.
60. *Bridelia mollis* Hutchinson.
    Bridelia spp.
63. *Croton barotsensis* Gibbs.
    gratissimus Burch.
    rivularis Mull. Arg.
    zambesiacus Oliv.
    Croton spp.
122. *Acalypha peduncularis* Meissn.
    petiolaris Hochst.
    villicaulis Rich.
    zambesica Muell. Arg.
    Acalypha spp.
131. *Tragia angustifolia* Benth.
    Gardneri Prain.
    mitis ?
    rhodesiæ Pax.
139. *Ricinus communis* L.
178. *Ricinodendron* spp.

193. *Excœcaria* sp. ?
200. *Maprounea* sp. ?
213. *Euphorbia abyssinica.*
    angularis Klotzsch.
    benguellensis Pax.
    ericoides Lam.
    Eylesii Rendle.
    grandidens Haw.
    griseola Pax.
    helioscopia L., var.
    heterophylla ?
    matabelensis Pax.
    Oatesii Rolfe.
    Reinhardtii (Volk) Pax.
    tettensis Boiss.
  Euphorbia spp.

149. BUXACEÆ.

3. *Buxus Macowani* Oliv.

153. ANACARDIACEÆ.

16. *Sclerocarya caffra* Sond.
  Sclerocarya spp.
21. *Lannea discolor* (Sond.) Engl.
    edulis (Sond.) Engl.
    Schimperi Hochst.
  Lannea spp.
47. *Heeria insignia* O. Kuntze., var. *reticulata* Baker f.
    pulcherrima (Schweinf.) O. Kuntze.
    reticulata (Baker) Engl.
52. *Rhus bulawayensis* Diels.
    glaucescens Rich.
    lancea L. f.
    leptodictya Diels.
    mucronifolia Sond.
    paniculosa Sond.
    tenuinervis Engl. var.
    trifoliata Baker f.
    villosa L. f.
    Welwitschii Engl., var. *angustifoliola* Baker f
  Rhus spp.

157. AQUIFOLIACEÆ.

1. *Ilex capensis* Sond. and Harv.

158. CELASTRACEÆ.

10. *Gymnosporia buxifolia* (Sond.) Szyszy.
    senegalensis Loess.
    senegalensis Loess., var. *inermis.*
    senegalensis Loess., var. *spinosa.*
  Gymnosporia spp.
12. *Catha edulis* Forsk.

23. *Elaeodendron matabelicum* Loess.
Elaeodendron sp.

159. HIPPOCRATEACEÆ.

2. *Hippocratea cymosa* De Willd. and Th. Dur.
obtusifolia Roxb.

165. SAPINDACEÆ.

2. *Paullinia pinnata* L.
4. *Cardiospermum corindum* L.
12. *Allophylus alnifolius* (Baker) Radlk.
Allophylus sp.
62. *Pappea capensis* E. and Z.
Pappea sp.
109. *Dodonæa viscosa* L.

167. MELIANTHACEÆ.

1. *Bersama maschonensis* Gurke.
Swynnertoni Baker f.

168. BALSAMINACEÆ.

1. *Impatiens Cecili* N. E. Br.
Impatiens sp.

169. RHAMNACEÆ.

4. *Zizyphus espinosus* ?
jujuba, Lam., var. *nanus* Engl.
mucronata Willd.
Zeyheriana Sond.
Zizyphus spp.
18. *Rhamnus* sp.
48. *Helinus mystacinus* Hemsl.
ovatus E. Mey.

170. VITACEÆ.

1. *Vitis* sp ?
2. *Ampelocissus obtusata* Planch.
9. *Rhoicissus erythrodes* Planch.
erythrodes Pl., var. *ferruginea.*
Rhoicissus sp.
10. *Cissus crotalarioides* Planch.
cymosa Schum.
gracilis Guill. and Perr.
hypargyrea Gilg.
jatrophoides Planch.
Marlothii Gilg.
rhodesiæ Gilg.
Cissus spp.

174. TILIACEÆ.

17. *Corchorus asplenifolius* Burch.
    hirsutus L.
    mucilagineus Gibbs.
    muricatus Hochst.
    serræfolius Burch.
    tridens L.
    trilocularis L.
  Corchorus spp.
21. *Sparmannia* sp.
30. *Grewia cana* Sond.
    flava DC.
    monticola Sond.
    occidentalis L.
    pilosa Lam.
  Grewia spp.
39. *Triumfetta annua* L.
    effusa E. Mey.
    laxiflora Engl.
    Mastersii Baker f.
    rhomboidea Jacq.
    Welwitschii Mast.
  Triumfetta spp.

175. MALVACEÆ.

4. *Abutilon angulatum* Mast.
    Cecili N. E. Br.
    fruticosum Guill. and Perr.
    hirsutissimum Moench.
    matopense Gibbs.
    zanzibaricum Bojer.
6. *Wissadula hernandioides* Garcke.
    rostrata Planch.
19. *Sida cordifolia* L.
    longipes E. Mey.
    rhombifolia L.
  Sida sp.
27. *Urena lobata* L.
28. *Pavonia clathrata* Masters.
    macrophylla E. Mey.
    Meyheri Masters.
  Pavonia spp.
34. *Hibiscus Allenii* Sprague and Hutchinson.
    articulatus Hochst.
    cannabinus L.
    micranthus L.
    micranthus L., forma *macranthus*.
    mutatus N. E. Br.
    panduriformis Burm.

pentaphyllus F. Muell.
physaloides Guill. and Perr.
pusillus Thunb.
rhodanthus Gurke.
rhodesicus Baker f.
Solandra L. Her.
surattensis L.
ternatus Masters.
trionum L.
vitifolius L.
Hibiscus spp.
36. *Kosteletzkya Buttneri* Garke.
Kosteletzkya sp.
39. *Thespesia Garckeana* F. Hoffm.
Thespesia spp.
41. *Gossypium* sp. ?

177. BOMBACACEÆ.

1. *Adansonia digitata* L.

178. STERCULIACEÆ.

4. *Melhania Forbesii* Planch.
linearifolia Sond.
obtusa N. E. Br.
prostrata DC.
prostrata Burch., forma *latifolia*.
Randii Baker f.
10. *Dombeya densiflora* Planch.
rotundifolia Harv.
Dombeya sp.
13. *Hermannia abyssinica* Hochst.
boraginiflora Hook.
brachypetala Harv.
depressa N. E. Br.
rhodesiaca Engl.
viscosa Hiern.
Hermannia spp.
14. *Melochia corchorifolia* L.
16. *Waltheria americana* L.
40. *Sterculia Livingstoniana* Engl.
Sterculia spp.

182. OCHNACEÆ.

1. *Ochna Antunesii* Engl. and Gilg.
arborea Burch.
floribunda ?
leptoclada Oliv.
pulchra Hook f.
Schweinfurthiana F. Hoffm.
Ochna spp.

187. GUTTIFERÆ.

7. *Hypericum Lalandii* Choisy.
   lanceolatum Lam.
11. *Psorospermum* sp.
38. *Garcinia Livingstonei* T. And.

188. DIPTEROCARPACEÆ.

18. *Monotes africanus* A. DC.
   africanus A. DC., var. *denudans.*
   africanus A. DC., var. *glabra* Oliv.
   glaber Sprague.
   hypoleucus Gilg.

189. ELATINACEÆ.

1. *Bergia decumbens* Planch.

198. VIOLACEÆ.

14. *Hybanthus enneaspermum* Vent.
   Hybanthus sp.
17. *Viola abyssinica* Steud.

199. FLACOURTIACEÆ.

10. *Oncoba spinosa* Forsk.
   Oncoba sp.
25. *Paropsia reticulata* Engl.
30. *Scolopia Zeyheri* ?
   Mundii ?
53. *Flacourtia Ramontchi* L. Her.
   Flacourtia spp.
54. *Doryalis caffra* Sim. ?
   longissima ?
   Doryalis sp.

201. TURNERACEÆ.

1. *Wormskioldia lobata* Urban.
   longipedunculata Mast.
   Petersiana.
   tanacetifolia Klotz.
   Wormskioldia spp.
2. *Streptopetalum serratum* Hochst.

203. PASSIFLORACEÆ.

7. *Tryphostemma apetalum,* var. *serratum* Baker f.
   Mastersii.
   pedatum Baker f.
   Tryphostemma spp.
8. *Adenia senensis* Engl.

214. THYMELAEACEÆ.

7. *Gnidia Kraussiana* Meissn.
   microcephala Meissn.
   microphylla Meissn.
   Gnidia spp.

216. LYTHRACEÆ.

1. *Rotala cataractæ* Koehne.
   heteropetala, var. *Engleri* Koehne.
   longistyla Gibbs.
   Rotala spp.
2. *Ammannia baccifera* L.
   senegalensis Lam.
4. *Lythrum sagittifolium* Sond.
14. *Nesæa floribunda* Sond.
   passerinoides Koehne.
   radicans Guill. and Perr.
   rigidula Koehne.
   sagittifolia Sond.
   Stuhlmannii Koehne.
   triflora H. B. Kunth.
   Nesæa spp.

221. COMBRETACEÆ.

3. *Combretum apiculatum* Sond.
   apiculatum Sond., var. *parvifolium* Baker f.
   arbuscula Engl.
   atelanthum Diels.
   Bragæ Engl.
   cataractarum Diels.
   cognatum Diels.
   erythrophyllum Sond.
   glomeruliflorum Sond.
   Gueinzii Sond.
   hereroense Schinz.
   holosericeum Sond.
   imberbe Wawra.
   microphyllum Klotzsch.
   platypetalum Welw.
   primigenum Marloth and Engl.
   rhodesicum Baker f.
   salicifolium E. Mey.
   Schinzii ?
   taborense ?
   tetraphyllum Diels.
   Zeyheri Sond.
   Combretum spp.
9. *Terminalia prunioides* Laws.
   Randii Baker f.
   sericea Burch.

sericea Burch., var. *angolensis* Hiern.
silozensis Gibbs.
spinosa Engl.
Stuhlmannii Engl.
trichopoda Diels.
Terminalia spp.

222. MYRTACEÆ.

31\. *Syzygium benguelense* (Welw.) Engl.
cordatum Hochst.
guineense DC.
huillense (Hiern.) Engl.
intermedium Engl.
Syzygium spp.

223. MELASTOMATACEÆ.

33\. *Dissotis debilis* Triana.
incana Triana.
phæotricha Hook f.
segregata Hook f.
Dissotis spp.

224. ŒNOTHERACEÆ.

1\. *Jussieua angustifolia* Lam.
diffusa Forsk.
repens L.
villosa Lam.
villosa Lam., var. *linearis* Oliv.
3\. *Ludwigia jussiæoides* Harv.
Ludwigia sp.
5\. *Epilobium hirsutum* L.
stereophyllum Fresen. forma.

227. ARALIACEÆ.

34\. *Cussonia natalensis* Sond.
spicata Thunb.

228. UMBELLIFERÆ.

1\. *Hydrocotyle asiatica* L.
30\. *Alepidea amatymbica* E. and Z.
98\. *Lichtensteinia* sp.
100\. *Heteromorpha arborescens* Cham. and Schlecht.
Heteromorpha spp.
146\. *Sium* sp.
162\. *Diplolophium zambesianum* Hiern.
224\. *Peucedanum araliaceum* (Hochst.) Benth. and Hook f.
fraxinifolium Hiern.
Peucedanum spp.

233. ERICACEÆ.

62. *Philippia milanjiensis* Britten and Rendle.

236. MYRSINACEÆ.

1. *Mæsa lanceolata* Forsk.
28. *Embelia oleifolia* S. Moore.
Embelia spp.

237. PRIMULACEÆ.

21. *Samolus valerandi* L.

238. PLUMBAGINACEÆ.

1. *Plumbago zeylanica* L.
4. *Ceratostigma plantagineum* ?

239. SAPOTACEÆ.

25. *Chrysophyllum argyrophyllum* Hiern.
34. *Mimusops Mochisia* Baker., var.
Zeyheri Sond., var. *laurifolia* Engl.

240. EBENACEÆ.

1. *Royena hirsuta* L.
pallens Thunb.
villosa L.
2. *Euclea Divinorum* Hiern.
Eylesii Hiern.
Kellau Hochst.
lancea Thunb.
lanceolata E. Mey.
lanceolata E. Mey., var. *angustifolia* Hiern.
lanceolata E. Mey., var. *confertiflora* Hiern.
lanceolata E. Mey., var. *parvifolia* Hiern.
macrophylla E. Mey.
multiflora Hiern.
undulata Thunb.
Euclea spp.
4. *Diospyrus* sp. ?

243. OLEACEÆ.

4. *Schrebera mazoensis* S. Moore.
Schrebera spp.
16. *Olea laurifolia* Lam.
verrucosa Link.
20. *Menodora heterophylla* Mons.
22. *Jasminum mauritianum* Bojer.
oleaccarpum Baker.
stenolobum Rolfe.
Jasminum spp.

245. LOGANIACEÆ.

14. *Strychnos matopensis* S. Moore.
pungens Solered.
spinosa Lam.
tonga Gilg.

23. *Nuxia dentata* R. Br.
viscosa Gibbs.
24. *Gomphostigma scoparioides* Turcz.
25. *Chilianthus arboreus* A. DC.
27. *Buddleia salvifolia* Lam.

246. GENTIANACEÆ.

3. *Sebæa barbeyiana* Schinz.
3A. *Exochænium exiguum* A. W. Hill.
grande Griseb.
macranthum A. W. Hill. ?
22. *Canscora diffusa* (Vahl.) R. Br.
Kirkii N. E. Br.
25. *Chironia humilis* Gilg.
humilis Gilg., var. *Wilmsii* Prain.
transvaalensis Gilg.
Chironia spp.
34. *Sweertia stellarioides* Ficalho.
67. *Limnanthemum indicum* Dur. and De Wild.
Thunbergianum Gris.

247. APOCYNACEÆ.

10. *Acokanthera venenata* G. Don.
11. *Carissa Arduina* Lam.
edulis Vahl.
edulis Vahl., var. *tomentosa* Stapf.
14. *Landolphia Buchananii* (Hallier f.) Stapf.
Kirkii Dyer.
Kirkii Dyer., var. *Watsonia*.
Landolphia sp.
33. *Gonioma Kamassi* E. Mey.
35. *Alstonia* sp.
41. *Diplorrhynchus mossambicensis* Benth.
49. *Lochnera rosea* Reichb.
71. *Rauwolfia* sp.

248. ASCLEPIADACEÆ.

19. *Chlorocodon Whytei* Hook f.
20. *Tacazzea Kirkii* N. E. Br.
30. *Cryptolepis oblongifolia* Benth.
producta N. E. Br.
37. *Raphiacme lanceolata* Schinz., var. *latifolia* N. E. Br.
longifolia N. E. Br.
procumbens Schlechter.
Raphiacme spp.
67. *Xysmalobium bellum* N. E. Br.
Cecilæ N. E. Br.
dispar N. E. Br.
gramineum S. Moore.
Holubii Scott-Elliott.

reticulatum N. E. Br.
68. *Schizoglossum aciculare* N. E. Br.
biflorum Schlech., var. *guelense* N. E. Br.
gwelense N. E. Br.
Carsoni N. E. Br.
chirindense S. Moore.
Pentheri Schlech.
strictissimum S. Moore.
70. *Kanahia glaberrima* N. E. Br.
71. *Margaretta Holstii* K. Schum.
Whytei K. Schum.
73. *Cordylogyne mossambicense* Schl.
77. *Gomphocarpus concolor* E. Mey.
81. *Asclepias aurea* Schl.
densiflora N. E. Br.
eminens Schl.
Engleri Schl.
fallax Schl.
fruticosa L.
glaucophylla Schl.
lineolata Schl.
palustris Schl.
physocarpa Schl.
Randii S. Moore.
reflexa Britten and Rendle.
scabrifolia S. Moore.
tenuifolia N. E. Br.
Asclepias spp.
100. *Pentarrhinum insipidum* E. Mey.
124. *Cynanchum chirindense* S. Moore.
præcox Schl.
Cynanchum sp.
139. *Sarcostemma viminale* R. Br.
155. *Macropetalum Burchelli* Dcne.
160. *Brachystelma Barberiæ* Harv.
164. *Ceropegia abyssinica* Dcne.
hispidipes S. Moore.
mazoensis S. Moore.
stenantha K. Schum.
tentaculata N. E. Br.
Ceropegia sp.
170. *Decabelone elegans* Dcne.
174. *Caralluma lateritia* N. E. Br.
175. *Stapelia gigantea* N. E. Br.
Marlothii N. E. Br.
177. *Huernia* sp.
201. *Marsdenia zambesica* Schl.
201B. *Swynnertonia cardinea* S. Moore.

249. CONVOLVULACEÆ.

1. *Cuscuta kilimanjari* Oliv.
    obtusiflora, var. *cordofana* Englm.
    planiflora Ten.
6. *Evolvulus alsinoides* L.
    Evolvulus spp.
11. *Seddera capensis* Hallier f.
24. *Jacquemontia capitata* G. Don.
26. *Convolvulus Randii* Rendle.
    sagittatus, var. *abyssinica* Hallier f.
    ulosepalus Hallier f.
    Convolvulus sp.
30. *Merremia angustifolia* Hallier f.
    kentrocaulos Rendle, var. *pinnatifida* N. E. Br.
    palmata Hallier f.
    pinnata Hallier f.
    pterygocaulos Hallier f.
    tridentata Hallier f.
33. *Astrochlæna malvacea* (Klotzsch) Hallier f.
    Astrochlæna malvacea (Klotzsch), var. epedunculata Rendle.
    Stuhlmanni Hallier f.
36. *Ipomoea angustifolia* Hallier f.
    angustisecta Engl.
    aquatica Forsk.
    blepharophylla Hallier f.
    cardiosepala Hochst.
    Cecilæ N. E. Br.
    coscinosperma Hochst., var. *hirta* Rich.
    crassipes Hook., var. *cordifolia* Rendle.
    crassipes Hook., var. *Thunbergioides* Hallier f.
    dammarana Rendle.
    eriocarpa R. Br.
    fragilis Choisy.
    fragilis Choisy, var. *Randii.*
    fragilis Choisy, var. *pubescens* Hallier f.
    Holubii Baker.
    involucrata Beauv.
    lilacina Bl. Bijdr.
    Lugardi N. E. Br., var. *parviflora* Rendle.
    obscura Ker.
    papilio Hallier f.
    pes-tigridis L.
    pilosa Sweet.
    pubescens Choisy, var. *pubescens* Hallier f.
    Randii Rendle.
    rhodesiana Rendle.
    shupangensis Baker.
    simplex, var. *obtusisepala* Rendle.

stenosiphon Hallier f.
verbascoidea Choisy.
Welwitschii Vatke.
Wightii Choisy.
Ipomoea spp.

252. BORAGINACEÆ.

1. *Cordia* spp.
6. *Ehretia amoena* Klotzsch.
caffra Sond.
hottentotica Burch.
Ehretia sp.
14. *Tournefortia* sp.
15. *Heliotropium marifolium* Retz.
ovalifolium Forsk.
zeylanicum Lam.
Heliotropium sp.
19. *Trichodesma angustifolium* Harv.
physaloides A. DC.
27. *Cynoglossum micranthum* Desf.
72. *Lithospermum* sp.

253. VERBENACEÆ.

6. *Verbena officinalis* L.
12. *Lantana salvifolia* Jacq.
Lantana sp.
13. *Lippia asperifolia* Rich.
Oatesii Rolfe.
Wilmsii Pearson.
16. *Bouchea pinnatifida* Schauer.
Wilmsii Gurke.
21. *Priva* sp.
30. *Duranta Plumieri* Jacq.
54. *Vitex Eylesii* S. Moore.
flavenscens Rolfe, var. *parviflora* Gibbs.
Gurkeana Engl.
isotjensis Gibbs.
Kirkii Baker.
obovata E. Mey.
Vitex sp.
59. *Clerodendron glabrum* E. Mey.
lanceolatum Gurke.
myricoides R. Br.
myricoides R. Br., var. *cuneatum* Pearson.
myricoides R. Br., var. *discolor* Baker.
ovale Klotzsch.
reflexum Pearson.
spinescens Gurke.

254. LABIATÆ.

4. *Tinnea rhodesiana* S. Moore.
    vestita Baker.
    zambesiaca Baker.
25. *Scutellaria Livingstonei* Baker.
27. *Acrotome* sp.
55. *Leonotis nepetifolia* R. Br.
    Randii S. Moore.
59. *Leucas capensis* Benth.
    martinicensis R. Br.
    milanjiana Gurke.
    neuflizeana Courbon.
    nyassæ Gurke.
    Randii S. Moore.
    stricta Baker.
Leucas spp.
81. *Salvia runcinata* L. f.
    stenophylla Bch.
Salvia sp.
119. *Mentha sylvestris* L.
128. *Pogostemon Rogersii* N. E. Br.
133. *Hyptis pectinata* Poit.
136. *Aeolanthus crenatus* S. Moore.
    sericeus Gurke, var.
Aeolanthus sp.
138. *Pycnostachys remotifolia* Baker.
    urticifolia Hook.
141. *Plectranthus floribundus* N. E. Br.
floribundus N. E. Br., var. *longipes* N. E. Br.
    matabelensis Baker.
    selukwensis N. E. Br.
    tuberosa ?
Plectranthus spp.
144. *Englerastrum Schweinfurthii* Briq.
146. *Coleus latifolius* Hochst.
    matopensis S. Moore.
    palliolatus S. Moore.
    polyanthus S. Moore.
    shirensis Gurke.
    umbrosus Vatke.
148. *Hoslundia opposita* Vahl., var. *decumbens* Baker.
153. *Acrocephalus sericeus* Briq.
Acrocephalus spp.
154. *Geniosporum angolense* Briq.
155. *Moschosma multiflorum* Benth.
    riparium Hochst.
156. *Hemizygia bracteosa* Briq.
157. *Ocimum canum* Sims.
    filamentosum Forsk.

hians Benth.
knyanum Vatke.
obovatum E. Mey.
Randii S. Moore.
scoparium Gurke.
Ocimum sp.
158. *Orthosiphon bracteosus* Baker.
Elliottii Baker.
Kirkii Baker.
linearis Benth.
rhodesianus S. Moore.
shirensis Baker.

256. SOLANACEÆ.

1. *Nicandra physaloides* Gaertn.
3. *Lycium tetrandrum* Thunb.
persicum Miers.
24. *Withania somnifera* Dunal.
25. *Physalis minima* L.
peruviana L.
31. *Solanum nigrum* L.
panduraeforme E. Mey.
sodomaeum, var. *Hermanni* Dun.
39. *Datura stramonium* L.
58. *Nicotiana tabacum* L.
60. *Petunia violacea* Lindl.

257. SCROPHULARIACEÆ.

2. *Celsia trigyna* L.
8. *Aptosimum decumbens* Schinz.
elongatum Engl.
lineare Marl. and Engl.
17. *Nemesia affinis* Benth.
dentata G. Don.
divergens Benth.
foetens Vent.
18. *Diclis petiolaris* Benth.
59. *Chaenostoma fissifolia*.
60. *Sutera atropurpurea* Hiern.
Burkeana Benth.
Carvalhoi Skan.
micrantha Hiern.
65. *Mimulus gracilis* R. Br.
73. *Limnophila ceratophylloides* Skan.
gratioloides R. Br.
sessiflora Blume.
76. *Stemodiopsis Eylesii* S. Moore.
humilis Skan.
99. *Limosella tenuifolia*.

101. *Craterostigma nanum* Oliv.
plantagineum Hochst.
Craterostigma sp.
105. *Ilysanthes conferta* Hiern.
Muddii Hiern.
107. *Hebenstreitia Holubii* Rolfe.
109. *Selago Ceciliæ* Rolfe.
chongweensis Rolfe.
Hoepfneri Rolfe.
Selago spp.
138. *Melasma kilmandjarica* Hmsl.
pumila Benth.
sesssiliflorum Hiern.
157. *Sopubia cana* Harv.
leprosa S. Moore.
ramosa Hochst.
simplex Hochst.
163. *Buechnera dura* Benth.
Eylesii S. Moore.
rhodesiana S. Moore.
pusilliflora S. Moore.
Randii S. Moore.
Buechnera spp.
163A. *Eylesia buchneroides* S. Moore.
164. *Cycnium adoense* E. Mey.
palustre ?
165. *Rhamphicarpa fistulosa* Benth.
montana N. E. Br.
tubulosa Benth.
Rhamphicarpa sp.
166. *Striga elegans* Benth.
Forbesii Benth.
lutea Lour.
orobanchoides Benth.
Thunbergii Benth.

258. BIGNONIACEÆ.

55A. *Podranea Brycei* Sprague.
51. *Rhigozum brevispinosum* O. Kuntze.
83. *Markhamia acuminata* Sprague.
100. *Kigelia pinnata* DC., var. *tomentella* Sprague.

259. PEDALIACEÆ.

2. *Pterodiscus Elliottii* Baker.
speciosus Hook.
Pterodiscus sp.
4. *Harpagophytum procumbens* DC.
procumbens DC., var. *sublobatum* Engl.
9. *Rogeria adenophylla* J. Gay.

10 *Sesamum alatum* Thonn.
angustifolium Engl.
Baumii Stapf.
calycinum Welw.
capense Burmm.
11. *Ceratotheca Kraussiana* Kunth.
sesamoides Endl.
triloba E. Mey.
13. *Pretrea zanguebarica* J. Gay.

261. OROBANCHACEÆ.

5. *Orobanche minor* Sutt.

262. GESNERIACEÆ.

24. *Streptocarpus* sp.

264. LENTIBULARIACEÆ.

2. *Genlisea africana* Oliv.
4. *Utricularia exoleta* R. Br.
firmula Welw. ex Oliv.
Gibbsiæ Stapf.
Kirkii Stapf.
transrugosa Stapf.
Welwitschii Oliv.
Utricularia spp.

266. ACANTHACEÆ.

4. *Nelsonia campestris* R. Br.
9. *Thunbergia affinis* S. Moore.
alata Boj.
Bachmanni Lindau.
glaberrima Lindau.
lancifolia T. And.
oblongifolia Oliv., var. *Berringtonii* Burkill.
Randii S. Moore.
19. *Synnema acinos* S. Moore.
21. *Hygrophila cataractæ* S. Moore.
rhodesiana S. Moore.
24. *Mellera lobulata* S. Moore.
27. *Phaulopsis longifolia* T. Thoms.
parviflora Willd.
34. *Dyschoriste alba* S. Moore.
Fischeri Lindau.
matopensis N. E. Br.
Monroi S. Moore.
Perrottetii O. Kuntze.
radicans (T. And.) O. Kuntze.
Dyschoriste sp.

35. *Disperma densiflorum* C. B. Cl.
quadrisepalum C. B. Cl.
quadrisepalum C. B. Cl., var. *grandifolium* S. Moore.
viscidissimum S. Moore.
36. *Chaetacanthus Persoonii* Nees.
40. *Hemigraphis myosotiflora* Stapf.
prunelloides S. Moore.
48. *Strobilanthopsis hircina* S. Moore.
60. *Ruellia patula* Jacq.
praetermissa Lindau.
67. *Crabbea nana* Nees.
68. *Barleria albostellata* Clarke.
Boehmii Lindau.
capitata Klotzsch.
Eylesii S. Moore.
Mackenii Hook f.
matopensis S. Moore.
Meyeriana Nees.
Randii S. Moore.
spinulosa Klotzsch.
Barleria spp.
75. *Blepharis Bainesii* S. Moore.
boerhaaviaefolia Pers.
diversispina C. B. Cl.
innocua C. B. Cl.
Blepharis spp.
101. *Asystasia coromandeliana* Nees.
120. *Peristrophe usta* C. B. Cl.
Peristrophe sp.
125. *Dicliptera Melleri* Rolfe.
tanganyikensis C. B. Cl.
126. *Hypoestes aristata* (L.) Soland.
verticillaris R. Br.
149. *Rhinacanthus communis* Nees.
189. *Justicia Betonica* L.
betonicoides C. B. Cl.
debilis Vahl.
elegantula S. Moore.
exigua S. Moore.
flava Vahl.
matammensis Oliv.
prostrata (Nees) T. And.
protracta T. And., var.
Justicia spp.

270. RUBIACEÆ.

18. *Oldenlandia angolensis* K. Schum.
Bojeri Hiern.
caffra E. and Z.
capensis L.

cuspidata K. Schum.
decumbens Hiern.
Heynii Oliv.
hirtula O. Kuntze, forma.
lasiocarpa Hiern.
obtusiloba Hiern.
papillosa K. Schum.
rhodesiana.
thymifolia Prantl.
Welwitschii Hiern.
Oldenlandia spp.
36. *Pentas carnea* Benth.
nobilis S. Moore.
Woodii Scott-Elliott.
42. *Dirichletia pubescens* Klotzsch., var.
155. *Leptactinia lanceolata* K. Schum.
166. *Gardenia resiniflua* Hiern.
Thunbergia L. f.
Gardenia sp.
180. *Feretia aeruginescens* Stapf.
184. *Empogona Allenii* Stapf.
189. *Tricalysia pachystigma* K. Schum.
229. *Pentanisia rhodesiana* S. Moore.
sericocarpa S. Moore.
variabilis Harv.
Pentanisia sp.
232. *Vangueria infausta* Burch.
Randii S. Moore.
rhodesiana S. Moore.
velutina Hiern.
Vangueria spp.
233. *Plectronia abbreviatum* S. Moore (Engl.).
lanciflorum Hiern (Engl.).
Oatesii Rolfe (Engl.).
Randii S. Moore (Engl.).
Plectronia sp.
240. *Pachystigma lateritica* K. Krause (Engl.)
obovata N. E. Br. (Engl.).
stenophylla Welw. (Engl.).
tetraquetra K. Krause (Engl.).
Zeyheri Sond. (Engl.).
241. *Ancylanthus Bainesii* Hiern.
264. *Pavetta assimilis* Sond.
Cecilæ N. E. Br.
Eylesii S. Moore.
gardeniaefolia Hochst.
luteola Stapf.
neurophylla S. Moore.
obovata E. Mey.

Schumanniana F. Hoffm.
stipulopallium K. Schum.
Pavetta spp.
319. *Anthospermum ciliare* L.
hispidulum E. Mey.
lanceolatum Thunb.
Randii.
rigidum E. and Z.
Anthospermum sp.
331. *Otiophora inyangana* N. E. Br.
scabra Zucc.
345. *Richardsonia scabra* St. Hil.
354. *Borreria dibrachiata* (Oliv.) K. Schum.
Ruelliæ K. Schum.
stricta K. Schum.
Borreria spp.
370. *Rubia petiolaris* DC.

274. DIPSACEÆ.

8. *Scabiosa columbaria* L.

275. CUCURBITACEÆ.

44. *Momordica balsamina* L.
involucrata E. Mey.
Morkorra A. Rich.
Momordica spp.
52. *Cucumis Cecili* N. E. Br.
Figarei Delile.
hirsutus Sond.
Cucumis sp.
61. *Trochomeria macrocarpa* Hook f.
Trochomeria sp.
81. *Coccinia palmata* Cogn.

276. CAMPANULACEÆ.

20. *Prismatocarpus* sp.
25. *Wahlenbergia caledonica* Sond.
mashonica N. E. Br.
Oatesii Rolfe.
undulata A. DC.
Zeyheri E. and Z.
Wahlenbergia spp.
27. *Lightfootia abyssinica* Hochst.
denticulata Sond.
glomerata Engl.
juncea (Buek) Sond.
tenuifolia A. DC.
Lightfootia sp.
38. *Cyphia alba* N. E. Br.
mazoensis S. Moore.

51. *Lobelia Boivini* Sond.
decipiens Sond.
fonticola Engl. and Gilg.
microdon A. DC.
minutidentata Engl. and Gilg.
natalensis A. DC.
thermalis Thunb.
truillifolia Hemsl. forma.
Lobelia spp.

280. COMPOSITÆ.

6. *Ethulia conyzoides* L.
12. *Erlangea Eylesii* S. Moore.
laxa S. Moore.
Schinzii O. Hoffm.
Erlangea spp.
18. *Bothriocline inyangana* N. E. Br.
23. *Vernonia Bainesii* Oliv. and Hiern.
fastigiata O. and H.
gerberaeformis O. and H.
glabra Vatke.
humilis C. H. Wright.
integra S. Moore.
Kraussii Sch. Bip.
lancibracteata S. Moore.
mashonica N. E. Br.
Melleri O. and H.
natalensis Sch. Bip.
Petersii O. and H.
podocoma Sch. Bip.
porphyrolepis S. Moore.
Poskeana Vatke and Hild., var. *chlorolepis* Steetz.
purpurea Sch. Bip.
Randii S. Moore.
senegalensis Less.
Steetziana O. and H.
Tenoreana O. and H.
vitellina ?.
Woodii O. Hoffm.
Vernonia spp.
47. *Elephantopus scaber* L.
57. *Adenostemma Dregei* DC.
viscosum Forst.
88. *Eupatorium africanum* O. and H.
90. *Mikania scandens* Willd.
137. *Grangea maderaspatana* Poir.
173. *Erigeron canadense* L.
191. *Felicia fasicularis* DC.
hyssopifolia Nees.
lutea N. E. Br.

simulans (Harv.) Engl.
tenella DC.
Felicia sp.
195. *Psiadia arabica* Jaub. and Spach.
197. *Nidorella depauperata* Harv.
hirta DC.
microcephala Steetz.
namaquensis ?
resedifolia DC.
198. *Conyza variegata* Shc. Bip.
208. *Brachylaena discolor* DC.
rhodesiana S. Moore.
rotundata S. Moore.
Brachylaena sp.
209. *Tarchonanthus camphoratus* L.
211. *Blumea gariepina* DC.
lacera DC.
212. *Laggera alata* Shc. Bip.
pterodonta Sch Bip.
221. *Denekia capensis* Thunb.
225. *Epaltes gariepina* Steetz.
227. *Sphaeranthus peduncularis* DC.
Randii S. Moore.
Steetzii O. and H.
244. *Amphidoxa* sp.
264. *Gnaphalium luteo-album* L.
278. *Helichrysum argyrosphaerum* DC.
caespititium Sond.
callicomum Harv.
cymosum Less.
declinatum Less.
ericaefolium Less.
Kraussii Sch. Bip.
leptolepis DC.
Saweri S. Moore.
setosum Harv.
stenopterum DC.
stenopterum DC., var. *citrinum* S. Moore.
Helichrysum spp.
327. *Athrixia elata* Sond.
333. *Inula glomerata* O. and H.
341. *Calostephane divaricata* Benth.
Calostephane sp.
345. *Pegolettia senegalensis* Cass.
350. *Pulicaria capensis* DC.
longifolia Boiss.
362. *Geigeria passerinoides* Harv.
protensa Harv., var. *pubigera* S. Moore.
pubescens S. Moore.

Randii S. Moore.
rhodesiana S. Moore.
Zeyheri Harv.
Geigeria spp.
419. *Xanthium spinosum* L.
440. *Sclerocarpus africanus* Jacq.
440. *Wedelia africana* P. Beauv.
diversipapposa S. Moore.
Wedelia spp.
466. *Aspilia Eylesii* S. Moore.
vulgaris N. E. Br.
zombensis Baker.
Aspilia sp.
493. *Guizotia abyssinica* Cass.
Eylesii S. Moore.
498. *Coreopsis insecta* S. Moore.
Steppia Steetz. forma.
Coreopsis sp.
503. *Chrysanthellum procumbens* Pers.
508. *Bidens pilosa* L.
Schimperi Sch. Bip.
533. *Jaumea compositarum* Bth. and Hk.
582. *Tagetes glandulifera* Schrank.
minuta L.
622. *Cotula anthemoides* L.
627. *Schistostephium artemisiifolium* Baker.
heptalobum Bth. and Hk.
629. *Artemisia afra* Jacq.
645. *Gongrothamnus* sp.
676. *Gynura cernua* Benth.
crepidioides Benth.
sarcobasis DC.
vitellina Benth.
677. *Cineraria mazoensis* S. Moore.
682. *Senecio barbertonicus* Klatt., var. *microcephala* S Moore.
bupleuroides DC.
discifolius Oliv.
erubescens Ait.
lasiorhizus DC.
latifolius DC.
longiflorus O. and H.
othonnaeflorus DC.
picridifolius DC.
protracta (S. Moore) Engl.
Randii S. Moore.
rosmarinifolius L. f.
sagittata (DC.) Engl.
sarmentosus O. Hoffm.
serra Sond.

tenellulus S. Moore.
Senecio spp.
688. *Euryops osteospermum* S. Moore.
Euryops osteospermum S. Moore., var. *parvifolia* S. Moore.
691. *Othonna ambifaria* S. Moore.
698. *Osteospermum herbaceum* L. f.
moniliferum L.
muricatum E. Mey.
699. *Tripteris amplexicaulis* Less.
Tripteris sp.
703. *Arctotis scaposa* (Harv.) Engl.
705. *Gazania Krebsiana* Less.
Gazania Krebsiana Less., var. *hispidula* Harv.
707. *Berkheyopsis integrifolia* Volkens.
Berkheyopsis sp.
709. *Berkheya Adlami* Hook f.
subulata Harv.
Zeyheri Sond. and Harv.
747. *Centaurea rhizocephala* O. and H. var. *australis*.
Centaurea sp.
769. *Pleiotaxis Antunessii* O. Hoffm.
771. *Dicoma anomala* Sond.
Dicoma anomala Sond., var. *microcephala* Harv.
Dicoma anomala Sond., var. *Sonderi* Harv.
Kirkii Harv.
sessiflora Harv.
tomentosa Cass.
798. *Gerbera abyssinica* Sch. Bip.
discolor Sond.
viridifolia Sch. Bip
piloselloides Cass.
plantaginea Harv.
831. *Tolpis* sp. ?
865. *Sonchus Elliottianus* Hiern.
macer S. Moore.
866. *Lactuca capensis* Thunb.
virosa Thunb.

Metallurgical Operations.—A new edition of Prof. A. H. Sexton's "Elementary Metallurgy" has just been published*—the fifth since 1894, when this particularly concise and useful little manual first appeared. Essentially a student's handbook, it is not overburdened with details, the principles on which metallurgical processes are based being afforded chief consideration. Broadly the manual divides into two portions, general and special. The first eight chapters deal with the properties of

* A. H. Sexton: *Elementary text-book of metallurgy*. London: C. Griffin and Co., Ltd., 1911. sm. 8vo., pp. xv, 263. 6s.

metals, the occurrence of their ores, and the modes of preparing the latter for smelting. About one-half of this part of the book is devoted to fuels, furnaces, and the materials of which these consist. Thus the student is led up to the general principles of metallurgical processes. The next ten chapters are more specialised: four of these are assigned to iron and steel, after which the metallurgy of copper, lead, zinc, tin, silver, gold and mercury is particularly described. A chapter on alloys and one on the applications of electricity to metallurgy close this second section. Several exercises are appended for laboratory practice.

MICROKINEMATOGRAPHY.—In a recent issue of *Nature* (Vol 88, p. 213), illustrations are given of the latest application of the kinematograph, indicating another stage of technical attainment and another field in which it may supplement knowledge. This stage has been reached by extending its range so as to represent objects as seen through high microscopic powers. The objects are seen against a black background, and are lit up by lateral rays. As under these circumstances the bulk of the light rays are deflected from the surface of the object under examination relatively little of its internal structure is seen. Cell nuclei are, nevertheless, frequently quite distinct, and the kineto-nucleus of a trypanosome can be clearly followed in motion. Amongst other films prepared is one displaying the blood in actual circulation through the vessels of the living body. The action of leucocytes as body scavengers is also depicted in the surrounding and ingestion of a diseased red corpuscle by a white cell. Another film represents the condition of the blood in a case of relapsing fever: long spiral threads dart hither and thither upon the screen, impinging and receding alternately, now hooking themselves together and then disentangling again, the whole blood history of such an attack being shown. Not the least important of this application of the kinematograph lies in the fact that some of the actual changes which it depicts take place so rapidly that it is beyond the power of the unaided human retina to follow their sequence, but by reproducing them at a slower rate upon the screen the kinematograph helps us to a clearer perception of the actual nature of the process or alteration which takes place.

TRANSACTIONS OF SOCIETIES.

CHEMICAL, METALLURGICAL AND MINING SOCIETY OF SOUTH AFRICA.—Saturday, January 20th: Mr. H. A. White, Vice-President, in the chair.—"Some observations on ancient mine workings in the Transvaal": T. G. **Trevor.** The author differentiated between ancient and modern workings by treating all small workings for copper or iron as modern native (Bantu) workings, and all workings for gold and tin, as well as the copper and iron workings, which are of great extent, as presumably ancient in their origin. The ancient workings are extremely plentiful in some of the northern districts of the Transvaal, but extend no further south than the latitude of Pretoria. A general description of the workings was given, followed by details of several particular workings: these were grouped respectively as gold, copper and tin workings. If they were worked by natives at all, it would involve an acquaintance on their part with the metallurgy of tin and bronze, and a capability of dealing with copper by hundreds of tons. They should be referred to a time long anterior to the Bantu, and hence it was to be concluded that the ancient miners of Rhodesia and those of the Transvaal were one and the same people.

Geological Society of South Africa.—Monday, January 29th: Dr. E. T. Mellor, President, in the chair.—"Some aspects of geological work in South Africa" (Presidential address): Dr. E. T. **Mellor.** Commencing with some generalised remarks on the nature of geological work in a new country, the author pointed out how in every country closer scrutiny inevitably led to considerable modification of the broad sketches that marked the earlier stages of geological investigation. In the Witwatersrand economic reasons necessitated a degree of minute attention to trifling geological features altogether disproportionate to their ordinary geological significance. The importance of sampling operations was emphasised, as well as the desirability of securing careful records of shaft and borehole sections. The striking manner in which the town of Johanensburg has been influenced by local geological conditions was dwelt upon; this influence having been exerted on township boundaries, the positions of the main roads, and even on the locality of the cemeteries. In conclusion, the author directed attention to the wideness of the field of enquiry still open in relation to South African geology, and pleaded for a more extensive recording of actual observations by individuals. Some of these would be immediately useful, while others would in due course take their place in the foundation on which some important generalisation may afterwards be based, but, if carefully made, all such observations would retain their scientific value.

Cape Chemical Society.—Friday, March 1st: Prof. B. de St. J. van der Riet, M.A., Ph.D., President, in the chair.—"Temperature treatment of wine": Prof. P. D. **Hahn.** A matured wine had been sent from the Cape to Johannesburg, where it had been exposed to constant low temperature during winter. This had caused the wine to become turbid, the cold rendering insoluble the cream of tartar contained in the wine. The author found that wine kept in ice tanks for several weeks deposited a certain amount of cream of tartar, and could then be syphoned off clear, after which it failed to exhibit any indication of turbidity either on heating or cooling to abnormal temperatures; he concluded, therefore, that matured wine should be fined and bottled in cold chambers in order to avoid the possibility of subsequent cloudiness occurring owing to precipitation of cream of tartar.

NEW BOOKS.

Mabson, R. R.—*The Statist's Mines of Africa.* London: "The Statist." [1911]. $7\frac{1}{2}$ in. × 5 in., pp. xlii, 892. Maps. 21s. nett.

Gibson, J. Y.—*The Story of the Zulus.* London: Longmans, Green and Co., 1911. 8vo. pp. vi, 338. 28 oz. 7s. 6d.

THE PRESENT POSITION OF THE DISCUSSION AS TO THE ORIGIN OF THE ZIMBABWE-CULTURE.

By Richard N. Hall, F.R.G.S.

By the term "Zimbabwe Culture"—a term first employed by German scientists—is meant all the forms of culture displayed in the prehistoric rock mines, in the buildings of dressed stone, in the form of ceremonial once practised at Zimbabwe, and in the arts and manufactures once employed in some more or less remote period of time in Southern Rhodesia.

By the term "period" no definite period of time is implied, nor that the culture was necessarily displayed by different races. A period, its brevity or length, is simply determined by a manifest change in culture, either in evolution or devolution, or by the culture, or any one or more of its phases, falling into desuetude or oblivion.

By the term "subsequent squatters" is meant occupiers at a ruin after it had already fallen into ruins, after it had become abandoned by its original builders and occupiers, such subsequent squatters not being connected in any way with the original builders and occupiers.

The main problem which has excited the minds of acknowledged scientists of Britain, Germany, France, and South Africa is: What was the origin of the Zimbabwe-culture, also what were the approximate dates of the first displays of such various forms of culture so remarkably uncommon to any known negroid people?

There are only two working hypotheses which are possible of application to the solution of this problem, *viz.*:—

1. A natural evolution in culture of the altogether unaided Bantu negroid in mediæval times, as claimed by Dr. Maciver, and

2. The intrusion in some remote period of antiquity of an Asiatic influence the culture of which became engrafted at a much later time on the aboriginal culture of the Bantu negroid, either directly or conveyed through mixed Asiatic and African media, and, as in all instances of intrusions of foreign influence on African soil, whether in Egypt, Lybia, Carthage, or Somaliland, such imported culture after a period of display gradually weakened and suffered decadence, being overtaken in time by overburden and ultimate oblivion.

These two hypotheses, evolution of a purely local culture and a decadence of an imported culture, are diametrically opposed to each other. If one hypothesis be substantiated the other must perforce be negatived.

In the discussion of the *origin* of the Zimbabwe-culture, a discussion originated by Mr. Theodore Bent in 1891, and re-opened by the publication of Dr. Maciver's "Mediæval Rhodesia" in 1906, which was replied to in my volume "Pre-Historie a mass of arguments strengthening the hypothesis of an imported Rhodesia," there has been elicited from high scientific quarters and engrafted culture, as well as an accumulation of further local evidences in support of the case for the intrusion of a foreign culture.

This new material, confirmatory of the older evidences of an imported culture, many of these being dealt with in my "Pre-Historic Rhodesia," throws some additional light on the problem, and it is for the purpose of surveying the present position of the argument that I have prepared this paper.

My main guiding principle during almost sixteen years spent in attempting to unravel the mystery enshrouding our rock mines and buildings, has not been directed to secure a mere victory for the working hypothesis I have supported, but to ascertain the actual truth, even at the cost of having to throw over preconceived ideas, natural predilections, and long and tenaciously held theories as to the *origin* of the Zimbabwe-culture. I am still, to-day, perfectly open-minded to conviction if sufficient evidences pointing to other conclusions be forthcoming. But, I must honestly confess, so far, I altogether fail to discover them, and further, that the controversy raised by Dr. Maciver has shown me very clearly that my views are now fully accepted by the great bulk of the scientific world.

Thus, I read Dr. Maciver's "Mediæval Rhodesia," hoping to discover some new evidences as to *origin* which might, were it possible, prove to be more akin to actual probability than the argument which my evidences, gathered at over one hundred ruins, had compelled my reason to adopt. "Science," said Sir John Lubbock, "is but the exercise of an impartial common sense brought to bear on visible, tangible, and indisputably ascertained fact."

But, perhaps more so than could be the case with any other student of this question, whether in Britain, Germany, France, South Africa, or even in Rhodesia, no one could sympathise more with the argument for the natural and unaided evolution of the local negroid as explanatory of the Rhodesian phenomena than I could. For in my early days in Rhodesia I had held exactly the same theory of explanation as was elaborated twelve years later in Dr. Maciver's "Mediæval Rhodesia."

Without any previous conference with its author I knew exactly what the contents of the work necessarily must be before it was even published. No page in it was novel, for I was fully aware of what was bound to be urged. All the successive phases of my former evolutionist days were therein exactly and ideally well-described.

My co-worker and co-author, the late Mr. W. G. Neal, an exceedingly well-read and cultured man, whose powers of close observation are triumphantly vindicated by Dr. Maciver's volume, was a staunch upholder of the theory of an originally imported culture. I, as staunchly, was an evolutionist pure and simple, and my former evidences and arguments in support of that theory are most admirably set forth, quite unconsciously, by Dr. Maciver in his "Mediæval Rhodesia." His difficulties were identically my old difficulties.

For two years Mr. Neal and I discussed our rival hypotheses as to *origin* while engaged in spade-work within the actual ruins. There were, to my mind, far too many Kafir Kraal features about certain of the ruins and too much Kafir about certain of the relics to be associated with any suggestion of their being resultant of the intrusion of any Asiatic influence in ancient times.

Be it remembered that Mr. Neal had previously worked in the ruins in Mashonaland, where are admittedly the oldest ruins. I had then only examined ruins in Matebeleland, where the ruins are representative of the decadence in building from the original Zimbabwe construction.

The truth, it must be confessed, was that though certain buildings and relics in Matebeleland were obviously Kafir—though Kafir of from 500 to 900 years ago, or considerably more—I had altogether failed to enquire into the *origin* of even the Kafir culture displayed in such buildings and relics. Thus, sorely against my natural predilections for an evolved culture of purely Kafir origin, I was ultimately compelled to abandon my cherished hypotheses. For twelve months at least, while still doing spade-work in the ruins in Matebeleland, I felt horribly lost and miserable at the disappearance of my old conjectures. The study of the evolution and display of culture of a prehistoric people was then, to my mind, far more fascinating than the study of a gradual decadence of an imported culture and its ultimate fall into oblivion. All read with avidity of the building up of Rome and Athens, but few are sufficiently interested to care to read of their decline and fall. However, for the last twelve years my opinions have been reversed.

But the "ascertained facts" which led to this slow conversion seem after this lapse of time exceedingly simple. In the Matebeleland ruins, which represent a stage in the decadence of the Zimbabwe culture approaching Kafirisation; I found, what later hundreds of Rhodesians and experts from all parts of the world have also found.

1st. That in all extensions, additions, superstructures, and repairs, the workmanship is invariably and most obviously inferior to that of the original buildings, and just as these repairs, etc., are of various ages, so in each succeeding addition or repair there is a still further marked falling off in the builder's art until at last pure and unadulterated Kafir building, or, rather, the rude piling up of unhewn stones of all sizes and shapes of but a few score years ago, is reached. The old superior art of building in dressed stone, in true courses at last became dissolved into the rude rampant wall of Kafirisation.

But exactly the same powers of decadence in culture had been in operation in Mashonaland as in Matebeleland. In Mashonaland we see the decadent form of building not only scattered all over the country in parts where there are no other ruins, but cheek by jowl to the oldest structures which display the most perfected style of workmanship, the material of the older buildings having, in many instances, been specified by Bent, Willoughby, Schlechter, Neal, Hall, Franklin White, Francis Masey, and many other examiners, as material for the later and decadent form of building.

There is not the slightest doubt that "ascertained facts" revealed in construction overwhelmingly prove that the builders of the original structures in Matebeleland were contemporaries, if not the very identical people, who were among the early "subsequent squatters" at Zimbabwe, and the older type of structures in Mashonaland—that is, after the oldest ruins had become abandoned by their original builders and occupiers, and after the structures had fallen more or less into dilapidation and their floors became buried under wall *débris*.

Every ruin in Matebeleland is but a much later and poorer copy of the oldest Zimbabwe type of building. The Matebeleland culture in stone building was imported from Mashonaland. The remarkable similarity of all decadent "glorified Kafir kraal" ruins in Matebeleland and Mashonaland to each other, and the identical relics they yield, have been noticed by all archæologists who have visited this country. Professor Henry Balfour, but a few weeks ago, informed me that he agreed with my explanation given some twelve years ago, namely, that the builders of such decadent structures, being left entirely to their own resources, would, as they actually did, copy along identical lines common to all of them. Thus, as the culture in building gradually suffered decadence it resulted in a type of structure common in all parts of Southern Rhodesia, but varying considerably in essential features from the Zimbabwe Temple's excellent plan and method of construction. This the walls of the latest ruins most clearly demonstrate.

There is no evidence in any of our ruins, older or later, of any evolution in culture, but overwhelming evidences of prolonged processes of devolution, decadence, and dissolution. Not a single rudimentary structure leading up to the more perfected structure has ever been discovered, nor, if it be not scientifically wrong to say so, will it ever be discovered. To prove an evolution, the rudimentary stages of such evolution must first be established. This is a conclusion to which a hundred close observers of our ruins testify, a fact stated ten years ago in my first volume on our monuments, which statement remains unshaken, notwithstanding the fierce controversy that up to recently has been waged round this very question.

But I have said that the ruins in Matebeleland, such as Khami, Regina, Dhlo-dhlo, N'Natali, etc., are very much later than the finer structures of the original Zimbabwe type. This I have always maintained, and have claimed an interval of anything from 500 to 900 years between the erection of the present

Zimbabwe Temple and that of the earliest of the Matebeleland ruins and of the older decadent ruins throughout the country.

This Dr. Maciver himself to some extent allows for by his datings, for between his earliest datings for the erection of the Zimbabwe Temple given in his "Mediæval Rhodesia" and his earliest datings for the erection of the Matebeleland ruins he claims an interval of at least 500 years. He thus goes a long way to confirm my estimate of the relative ages of the Temple and the Matebeleland ruins.

But in the *Encyclopædia Britannica* he places the date of the Temple back to possibly the eleventh century. This is a present of 200 years. For the sake of mere argument we will accept this later dating, but most certainly not as matter of fact Now, what is the logical sequence. According to Dr. Maciver we have the Temple, its perfected style of building, its wealth in undoubted pre-historic relics, and its ceremonial, *en fin*, its display of a superior culture. Seven hundred years later, on Dr Maciver's own showing, we have Khami, etc., with its obviously decadent walls, its absence of pre-historic relics and no ceremonial. He thus destroys his own theory of evolution, for in the seven hundred years is demonstrated nothing save devolution and decadence in culture and a descent to Kafirisation.

The Matebeleland ruins thus constitute archæological half-way houses in the scale of decadence between the more perfected style of the earliest Zimbabwe type of structure and the Kafirisation shown in the rude rampart walls of piled-up unhewn stones into which the originally imported Zimbabwe-culture after long centuries of display ultimately became dissolved.

The Matebeleland ruins can never assist us to determine the *origin* of the Zimbabwe-culture as exemplified at the Temple, but their walls and their relics very materially assist us to fill up the later gaps in the history of the Zimbabwe-culture in this country. But in seeking the origin of that culture, especially in building in dressed stone, we must still go back to the Zimbabwe Temple and its massive conical tower.

2nd. The second reason which brought about my conversion from the hypothesis of a natural evolution of the Bantu or negroid as explanatory of the Rhodesian phenomena was: that the relics found in the admittedly later ruins proved a gradual decadence in culture as time elapsed. This gradual petering-out of the more perfected culture in art, workmanship, and material of relic parallels exactly, and also contemporaneously, the gradual petering-out of the originally more perfected culture in building, plan, and construction to that of Kafirisation; and what is more important is, that just as exactly and as contemporaneously there is demonstrated a parallel petering-out of the culture of rock-mining for gold from the admittedly oldest, largest, deepest, and most skilfully worked gold mines until the shallow workings on outcrops of copper and iron ore are reached. The pre-historic rock-mining for gold, which constitutes the largest area of ancient mining known to the world, ultimately dissolved itself in washing river sand, and finally gold-washing as a general industry became abandoned, and the ores scratched for were only those of copper and iron.

The stages of decay in culture are also shown in the imported cult of worship and ceremonial passing into oblivion *before* the erection of any of the decadent types of building. Like all intrusions of foreign worship introduced on African soil, the conservative forms of religious practice of the negroid re-asserted themselves and swamped it in overburden and ultimate oblivion.

The change in culture, invariably from the comparatively perfect to the altogether crude, is also demonstrated in the location and association of relics and finds.

In the Matebeleland ruins, as in all decadent ruins, and also in the *débris* banks of "subsequent squatters" at the old Zimbabwe type of buildings, the relics and finds are totally inferior in design, material, and workmanship to the class of relics found on the buried original floors of the Zimbabwe Temple. This is an obvious fact known to a hundred examiners, local and Europeans. The extraordinary profusion of highly ornate gold articles on the original floors of the Temple ultimately is replaced by a profusion of crudely made iron, copper, and brass articles found in the *débris* of "subsequent squatters" at Zimbabwe, *and also on the original floors of all decadent ruins.* Dr Maciver mainly worked in decadent ruins. He found certain Kafir structures, *ergo*, he argues, all the buildings in Rhodesia are purely Kafir; he finds certain Kafir articles in such ruins, *ergo*, he argues, all the relics are purely Kafir.

But what completed my conversion from the evolution theory may be stated as follows:

(*a*) There is a complete absence of rudimentary structures leading up to Zimbabwe and the older ruins, and no rudimentary conical towers. There can be no evolution without rudimentary stages.

(*b*) The Zimbabwe-culture is displayed on one defined area of South Africa only, and the area of buildings strictly corresponds to, and is coterminous with, the area of the pre-historic rock mines.

(*c*) The Karanga, who, according to definite historical records, have occupied this area for 700 years, if not 900 years, and who are of Nyanji origin, as Dr. Livingstone, Sir H. H. Johnstone, Werner, and other authorities claim, never laid one stone upon another, or worked rock for gold in the country of their origin.

(*d*) The ethnological evidences advanced by all South African authorities, from John Barrow in 1797 to Dr. Passarge in 1907, explicitly show there could have been no natural and unaided evolution of any Bantu people which could have produced, within Dr. Maciver's mediæval and post-mediæval period the Zimbabwe-culture, in rock-mining, building, ceremonial, and relic. Rather, their story is one of devolution and not of evolution.

For instance, the *Si-boko*, which goes to the heart of every negroid and Bantu negroid ever born in Africa. Round the *Si-boko* the life, motives, energies, thought, oral literature, traditions, and mythology of the Bantu revolve. But what is the *Si-boko* to-day? What has it been for the last ten centuries? Nothing but a traditionary Totemism, a mere shadow of a former substance, a Totemism, moreover, which is still slowly but surely decaying and losing its hold on the native mind. So decadent is it that in Rhodesia to-day, after only twenty years of partial contact with white civilisation and commerce, it is fast becoming but a feature of the hoary apst.

Again, decadence and devolution in arts and industries are equally manifest, and the processes of such decay were operating many centuries ago. The intrinsic native culture, such as it was, had commenced to die long prior to Dr. Maciver's hazarded period of its evolution. To-day, commerce is giving it its final *coup de grace*. Cotton-weaving has gone. Iron-working has gone, on the arrival of garden hoes made in Birmingham. The pottery industry has gone now that cheap hollowware, made in Germany, has made its appearance. Cheap Kafir stores have completed the natural decadence of the Bantu, in religion, arts, and industries. In short, South African ethnography provides not the slightest evidence of any evolution on the part of the altogether unaided Bantu rising to the level of the Zimbabwe-culture.

(*c*) Had there been no preceding rock-mining operations on this area there could have been no resultant buildings, or any other phase of the Zimbabwe-culture. There would have been no Zimbabwe Temple had it not been for the antecedent rock mines.

I have purposely left the *crux* of this argument until the second and concluding part of this paper.

We need not here discuss the Zimbabwe Temple, but, old and ancient as is the Temple, undoubtedly of pre-Koranic introduction, the Temple in its turn is but a later, a far later, resultant phase of the antecedent exploitation for gold from our rock mines which in expert mining opinion was commenced in these regions in ancient times—ancient in the very fullest sense of the term. The actual date of the erection of the Temple no more—and most probably still less—determines the date of the commencement of the Asiatic intrusion for gold than does last year's date of the erection of the Cape Town Cathedral determine the advent some centuries ago of the first Europeans in Cape Colony.

Any attempt, therefore, to solve the problem of the *origin* of the Zimbabwe-culture on archæological grounds, as Dr Maciver attempted to do, must inevitably fail.

Zimbabwe is not Rhodesia's most ancient monument by many centuries. Such a statement, when first put forward some twelve years ago, was at best but a reasonable conjecture on the balance of probabilities. To-day we occupy far surer ground, for we now know on positive irrefutable evidences that when the earliest exploitations of the gold from our rock mines took place, and when Zimbabwe was not standing, the Bantu races had not arrived south of the Zambesi on to the rock mine area. Bantu labourers no doubt assisted to build Zimbabwe Temple as labourers, and as labourers only, but under whose direction, and whose influence, and for whose purpose? The Temple, with its special arrangement and symbols of worship, so completely foreign to anything suggested by the study of the negroid from the time of Ptolemy to the present day, was not the outcome of any natural inspiration of the unaided Bantu then freshly arrived from northern regions.

The only aboriginal negroid on this area prior to the Bantu was the Bushman, who of a surety never extracted 150 million pounds sterling worth of gold from our rock mines. The Hottentots were never here.

It will be remembered that in 1894, four years after the Occupation of Mashonaland, and only one year after the Occupation of Matebeleland, Mr. John Hays Hammond, a consulting mining engineer, experienced in mining, ancient and modern, in all parts of the world, and also consulting engineer to the Chartered Company, reported, when less than a quarter of our present gold-mining areas had been discovered, as follows:—

1. That many of the rock mines in this country were undoubtedly ancient.

2. That the oldest rock mines showed by far the greatest skill in mining, and were the largest and deepest.

3. That there had been periods in mining, marked by lapses and sudden cessations in operations, each successive period showing a falling off in skill, in depth reached, in nature of the rock worked, and in extent of reef extracted.

4. That the skill in mining displayed on the oldest mines was beyond the capacity of any negroid or Bantu people to evolve or carry on, and was exactly paralleled in ancient mines in Asia.

5. That from the oldest mines not only had many scores of millions of pounds worth in modern value of gold been extracted, but the gold so won had been exported from the country and never used locally.

6. That Bantu people had for some centuries back down to relatively recent times mined not for gold but for iron and copper only; but this was confined to outcrops of reefs and shallow scratchings on the surface, and showed a most crude, careless method of securing and treating the ores.

This report was published in 1896, when less than a quarter of our present gold areas, and far less than a quarter of our ancient workings, had been discovered.

In 1897, Mr. Telford Edwards, another consulting mining engineer of high repute, confirmed Mr. Hammond's findings, and, moreover, estimated that, from the number, size, length and depth, and the values of the ores extracted, the ancient workings had produced, on a 50 per cent. reduced estimate of ores owing to the absence of modern reduction plant, gold to the present value of anything between 75 millions and 150 millions of pounds sterling, all of which quantity had been exported out of the country.

But since those early days additional ancient workings, some of immense size, have been discovered every month, and others are constantly being come upon. Out of the 129,000 mining claims registered and current for 1910, at least eleven-twelfths of the blocks are pegged on the sites of pre-historic workings.

Mr. Telford Edwards was the first authority to claim that there were ancient gold mines in Rhodesia centuries older than the Zimbabwe Temple and its associated type of buildings throughout the country, a claim which is supported by a great number of authorities conversant with both rock mines and ruins, and so obvious and overwhelming are the evidences pointing to this conclusion that the claim is impossible of disproof.

In my " Pre-Historic Rhodesia," three years ago, I gave the names of fully two score of consulting mining engineers in Rhodesia, who, on their own properties, and on their own independent evidences and experiences, amply confirmed the reports of Mr. John Hays Hammond and Mr. Telford Edwards.

In 1906 Mr. Rhodes collected from our mining engineers descriptions of the pre-historic gold workings, with plans, sections, assay values of ores extracted, and methods of mining employed. This collection he took to Europe and laid it before the highest known and accepted authorities on ancient mining in other countries, and he was informed that the oldest and finest rock mines in Rhodesia were undoubtedly of Asiatic origin, but that later negroids were responsible for the later and cruder shallow workings and outcrop scratchings.

Five years ago Professor Gregory, of Glasgow, examined some of our rock mines and reported the oldest to the British Association as being unmistakably ancient and the work of other people than the Bantu, while the later workings he considered to be those of local negroids.

A short while ago, Mr. H. A. Piper, the consulting engineer of the Consolidated Goldfields of South Africa, and of the Globe and Phœnix Mine, who for the past sixteen years has been engaged in examining and reporting on mining properties in Rhodesia, told me without the slightest hesitation: " I thoroughly agree with every word you have written on this question."

The Globe and Phœnix Mine, says Mr. Piper, alone contributed over a quarter of a million pounds' worth of gold to the pre-historic miners, and this estimate, he adds, makes most liberal allowances for crude methods of working, and the absence of reduction plant and cyanide process, and modern times treatment. But the Globe and Phœnix is only one of hundreds of properties which have been, or still are being operated upon, on which are extensive pre-historic workings.

It is toying with the problem to suggest, as does the author of "Mediæval Rhodesia," that this inconceivably vast amount of gold was mined for and exported between the eleventh and seventeenth centuries of this era. Historic record of these gold regions, commencing with Massoude, Alburuni, and El Wardi in the tenth century, Edrisi, Ibn Sayd, El Bakoni and Abd-el-Rassai in the twelfth century, all describe our natives as barbarians, and as ignorant of the real value of gold, to which they preferred iron and brass, as obtaining what gold dust they traded by washing sand in river-beds, which gold we are told they bartered for brass, glass beads, and cocoa-nuts.

Be it also remembered, that the bartering with natives for gold dust obtained by washing river sand, as recorded by Arabian, Persian, and Portuguese historians of this country, commencing at the end of the ninth century and continuing until the eighteenth century, be the amount great or small—and the historians were disgusted with its paltry amount—does not explain or account for a single pennyweight or grain of the many scores of millions of pounds' value of gold once extracted from the rock mines of Rhodesia. Moreover, the mediæval chroniclers have not a single word to say of the rock mines, save that they were "ancient," "most ancient," that they were so old that they were the mines from which the gold of Solomon was obtained, that in their time they never yielded a single grain of gold, and that the natives possessed no shred of tradition as to who had worked in them

But there is another important aspect of our pre-historic rock-mining remaining to be considered. The mining papers, on technical mining grounds, emphatically dissented from Dr. Maciver's hazarded conjecture as to the period of Rhodesia's pre-historic gold output. But on other grounds, in which finance journals also joined issue with Dr. Maciver, was the objection raised. When was all this vast amount of gold bullion placed on the gold market of the world? Not, they contended, within the last 1,500 or 2,000 years. I am not now speaking of gold from surface scratchings or river-bed sand of the decadent period. Gold was not then a world-wide currency as it is to-day. It could only have been so placed, without disturbing standard values, had its import into Asia covered centuries of time. This is exactly paralleled by our local evidences. The histories of ancient Western Asia are only now being opened; most of them are still closed volumes. What they may have to say as to Rhodesia's ancient gold output cannot at present be conjectured. But just as Professor Sayce, Professor Ramsay, and Dr. Keane, three of the greatest scholars of Biblical antiquities, have informed me that Arab and Indian records yet unexamined may, and probably will, throw considerable additional light on the plan, conical tower, stone birds, rosetted cylinder, phalli, and other religious symbols found at Zimbabwe, so may Arab, Persian, and Indian records, when examined, most probably throw additional light on Rhodesia's ancient gold industry.

But an important feature accentuated to-day, far more so than in the Hammond, Edwards, and Rhodes times, is that our oldest rock mines parallel in probable period of antiquity, in mining methods adopted, and in degree of skill in mining, the undoubted ancient gold mines in India, especially those in Northern Mysore. Mining engineers who are acquainted with the mines in both countries point without hesitation to the community in origin of both. In very recently published articles this has been made apparent. A *primâ facie* case for the consideration of such a community of origin has been established.

Now let me briefly revert to the Bantu who have occupied this area. According to the conjectured datings of the arrival of the Bantu south of the Zambesi, of several authorities, and taking from them a mean dating, we find that the oldest of the rock mines in the country had been worked long centuries prior to the descent of the Bantu hordes south of the Zambesi. Our oldest mines are prior to this invasion, and our decadent mines and the present Zimbabwe Temple are just subsequent to it. The arrival of the Bantu appears to have brought about a complete cessation of the more skilled rock-mining, which assuredly about that period met with some sudden catastrophe. The presence of the Bushmen, who up to that time had been the exclusive occupiers of this area, would have proved no hindrance to the taking of the gold. It certainly was not bartered for but simply exploited, fetched, and taken out of the country without let or prevention from any quarter.

The strong probability is that South Arabians of the ancient kingdom of Saba, referred to so frequently in Holy Writ as so rich in gold that they purveyed it to the Phœnicians, who were the trading intermediaries between Western Asia and Eastern Europe, which people of Saba then enjoyed the monopoly in navigation and trade in the Indian Ocean and its coasts, taking the treasures of all its countries to their emporium of Ophir in South Arabia, were the people who exploited our gold reefs, and that they employed Indian labour to work the mines.

The connection which, in some remote times, both European and South African anthropologists, ethnologists, and philologists strongly affirm to have once existed between Bantu, Semite, and Indian, would find a solution in this hypothesis, as also a reasonble explanation of the blurred form of the foreign culture displayed at Zimbabwe, *i.e.*, in the mixed media by which the culture was originally imported, translated, and displayed.

But the importance of pursuing researches into Arabian, Persian and Indian records has so far not been fully recognised. Mr. Rhodes sent Mr. Wilmot to Rome, and Dr. Theal to Europe to prosecute researches as to the mediæval and relatively modern history of this country. Had Mr. Rhodes been living the ancient records of Western Asia, so far as the Rhodesian activities were concerned, would ere now have ceased to be a sealed volume. This is a special work which only advanced classical scholars and recognised antiquarians with full knowledge of the East, and of strict impartiality, could undertake. Let us all hope the Beit or Rhodes Trustees may soon act on this friendly hint.

The probable connection of India with this country is a most fascinating phase for consideration. The Indian map of northern Zambesia, dating from the time of the Purans of the ancient Hindoos, discovered and republished by Captain Speke, is exceedingly valuable, seeing it gives Indian names of far inland typographical features of South-East Africa extending to 15° Lat. S., that is, southwards of the northern bend of the Zambesi River.

Again, we have Humboldt's account of the Cape of Good Hope, which was well known to Indian navigators as Cape Diab, "the two waters," two centuries prior to its rediscovery by Diaz in 1486.

And further, we have Massoude's account (915 A.D.) of the trade in gold between Sofala (Rhodesia's ancient seaport) and India, which, with the export of Rhodesian ivory to China, was a commerce which had flourished for centuries even before his time.

Livingstone, Chapman, Burton, Kirk, and all authorities on Zambesia down to the present day have called attention to the great number of plants, fruits, and trees of Indian *habitat* to be found together on our gold mines area. These are, of course, not indigenous to this country. We have the now wild *Tonge manga*, a cotton of Indian origin, not the *Tonge cadja*, which is indigenous; also a bean, *cajanus Indicus*, known in India as the Doll Plant; also the Indian fig now grown wild; also a tree, *matuvi*, found elsewhere only in India; and also the *Mahobohobo*, which has its *habitat* only in Southern India and Malayia. Here, this tree is only found on the area of the pre-historic rock mines, but the vast extent of country its forests now cover demonstrate that it arrived in some exceedingly remote times, and, being an Indian fruit tree, it was in all probability introduced by Indians.

Massoude, our earliest historian, in describing his voyage to China, which he took in the last decade of the ninth century, mentions the number of Arab colonies on all the eastern and southern Asian coasts, and he goes on to say that side by side with each such colony were large affiliated colonies of Indians.

Arabs and Indians, the Indians always occupying subsidiary positions, have from time immemorial been associated in their settlements, commerce and labour, at all East African and South-East African ports from Cape Gardafui to Zanzibar, and from Zanzibar to Mozambique and Sofala.

I have advanced the arguments and evidences given in this paper with a large amount of confidence which I thoroughly believe to have ample warrant and justification. The Khami Ruins at Bulawayo afford ocular demonstration in their walls of any archæological argument I have here employed. One can visit from that centre innumerable pre-historic buildings and rock mines. There we are in the mediæval country of Mo-Karanga with its almost one thousand years of written history. The direct representatives of the nation and dynasty of the old *Munu-mu-tapas*, the Karanga, are at this very moment busily working in stores and offices close at hand. To my confidence in the hypothesis which I have had the honour to advocate, must be added the great satisfaction that the recent controversy has but served to place the work of the late Mr. Theodore Bent in Mashonaland upon a still firmer and prouder pedestal.

A diagram illustrating the order of events in Pre-historic and Historic Rhodesia, and showing the relative periods of the Introduction, Display, and Decadence of the Zimbabwe-culture was laid before the meeting of the South African Association for the Advancement of Science at Bulawayo, and its purport may be stated as follows:—

Exclusive occupation of gold mines area by aboriginal Bushmen from some indefinite time until the arrival of Asiatics who mined for gold with Indian labour. These operations were continued for centuries, the gold being exported to Asia. Arrival of the Bantu on this area about 300 to 400 A.D., or a little later. Erection of Zimbabwe Temple and Tower at an indefinite time between 300 A.D. and 613 A.D., on a site which had been occupied by the Asiatic miners for a prolonged period earlier. Cessation of Asiatic influence, and sudden catastrophe putting an end to old form of rock mining. The Zimbabwe ceremonial falls into desuetude. Earliest decadent type of buildings erected, also crude mining for copper and iron in practice. Subsequent squatters at Zimbabwe and at other ruins of the oldest Zimbabwe type. The established trade in Rhodesian gold, obtained from river-beds, and exported to India, and its ivory exported to China (Massoude , 915 A.D.). Erection of Matebeleland Ruins (Khami, Dhlo-dhlo, etc.) about 900 A.D. River sand washing for gold general, also working on outcrops for iron and copper ores. The Bushmen practically exterminated. Arrival of Zarde Arabs. Inyanga, horticultural terraces, aqueducts, and labour shelter pits made and used, and the vine introduced from the Persian Gulf. Arrival of Magadoxo Arabs early in eleventh century at Sofala. Zimbabwe reputed to be "very ancient" and in ruins, the natives having no tradition as to its erection or original occupiers. In 1314, the Persians from Kilwa usurped the trade of the Arabs on the Sofala coast. Portuguese arrived and settled at Sofala, 1485. In 1560 all buildings said to be "ancient" and "most ancient," also the rock mines. Portuguese influence in Zambesia broken in 1760.

HELIOCENTRIC PLACES OF THE PLANET JUPITER.

By Robert T. A. Innes, F.R.A.S.

Mons. A. Gaillot of the Paris Observatory has called my attention to the fact that the comparison between the heliocentric places of the planet Jupiter derived from the *Nautical Almanac* and the *Connaissance des Temps* given in my paper on *Le Verrier's Theory of the Motions of Jupiter and Saturn** is not exact. He points out that the heliocentric places furnished by the *Connaissance des Temps* are corrected for nutation, whilst those of the *Nautical Almanac* are not, and that if we compare the right ascensions there will be a better accordance. Mons. Gaillot further states that, about the dates I have used, Le Verrier's Tables represent the motion of Jupiter as well if not better than those of Hill, but that this is accidental, and in a general manner comparison is more favourable to Hill's Tables.

I have therefore revised my little table and somewhat extended it. The places from the *Connaissance des Temps* have been brought to Greenwich Noon by multiplying the daily motion by + 0.00649 (— 9m. 20.9s. of E. Long.), and the "Obs." are the *Nautical Almanac* places corrected by photographic results obtained at the Greenwich Observatory and published year by year in the Monthly Notices of the Royal Astronomical Society.

Table 1.

Gr. Noon.		Right Ascension.			Declination.		
1908	N.A.	8h.	45m.	12.29s.	+ 18°	51′	35.4″
Jan. 29 ..	C. de T.			12.35			34.3
	Obs.			12.18			34.7
1909	N.A.	10	46	49.74	+ 9	15	13.1
Feb. 28 ..	C. de T.			49.71			11.9
	Obs.			49.58			12.0
1910	N.A.	12	37	53.49	— 2	20	28.6
Mar. 31 ..	C. de T.			53.42			29.5
	Obs.			53.51			29.0
1911	N.A.	14	30	46.10	— 13	23	29.8
May 1 ..	C. de T.			45.92			29.1
	Obs.			46.11			29.9
1912	N.A.	16	36	8.87	— 21	15	42.7
June 1 ..	C. de T.			8.60			42.7
1913	N.A.	18	56	22.72	— 22	54	59.9
July 5 ..	C. de T.			22.36			60.4

*Report S. A. Association for Advancement of Science, Cape Town, 1910, p. 104.

Table 2.

	N.A. — C.d.T.		Obs. — N.A.	
1908	— 0.06s.	+ 1.1″	— 0.11s.	— 0.7″
1909	+ 0.03	+ 1.2	— 0.16	— 1.1
1910	+ 0.07	+ 0.9	+ 0.02	— 0.4
1911	+ 0.18	— 0.7	+ 0.01	— 0.1
1912	+ 0.27	— 0.0		
1913	+ 0.36	+ 0.5		

It will be seen that in 1908-1910 errors of either set of tables were very small, and that Le Verrier's were the better in declination.

Here I would like to call attention to the cause of the slip I made, which does not in any way invalidate the argument of the rest of the paper. It arises from the injudicious practice of referring celestial co-ordinates to the two moving planes of the ecliptic and equator. A little reflection will show that in the case of heliocentric co-ordinates * the consideration of the shifting planes of so insignificant a planet as the Earth is gratuitous—the departure point and plane adopted in the *Connaissance des Temps* are in constant motion, and by quantities which are appreciable in a few hours. All consideration of the effects of the shifting of the ecliptic and Earth's equator should be left over until the preparation of the ephemeris in Right Ascension and Declination.

ACADEMY OF NATURAL SCIENCES, PHILADELPHIA.—The centenary of the foundation of the Academy of Natural Sciences of Philadelphia was celebrated on the 19th, 20th, and 21st March, 1912. The functions were attended by 144 representatives of other learned societies that had been invited to send delegates. The South African Association for the Advancement of Science was represented by one of its past presidents, Dr. Gardner F. Williams, M.A., LL.D., at present residing at Washington. At the opening meeting of the celebrations, which took place in the Academy's Lecture Hall at Philadelphia, the minutes of the Academy's first meeting, held on the 21st March, 1812, were read, and congratulatory letters and cables were presented from 184 scientific societies and institutions in various parts of the world, including the Department of Agriculture of the South African Union. An invitation reception held by the President of the Academy, the Hon. S. G. Dixon, M.D., LL.D., at the Bellevue-Stratford Hotel on March 20th, was attended by over one thousand guests. The proceedings concluded on the following evening with a banquet in the Lecture Hall of the Academy.

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* Heliocentric co-ordinates : the place of a planet as seen by an imaginary observer at the centre of the Sun.

A CONTRIBUTION TO OUR KNOWLEDGE OF THE REPRODUCTIVE ORGANS OF THE NUDIBRANCHIATA.

By Thomas Frederick Dreyer, B.A., Ph.D.

This paper is the result of work done preparatory to my former thesis (**1**) on the Nudibranchs; it has been written up in South Africa, and it is therefore impossible to give a good *résumé* of the recent literature. Its incompleteness is due to a lack of opportunity to work owing to my constant moving about in pursuance of my official duties. Only one species, *Doto fragilis*, have I been able to work up in detail; the others I shall describe briefly, diagrammatically.

Doto Fragilis.

Named specimens were obtained from the Board of Fisheries, Plymouth.

The relative sizes and positions of the various organs can, of course, be much better demonstrated by means of dissections, and for such information I can refer to Alder and Hancock (**2**), Fig. 15, Fam. 3, Pl. 4. These authors do not, however, label the various parts either fully or correctly; *e.g.*, what is really the hermaphrodite gland they take to be the same structure as that which they call "ovarium" in the genus *Eolis*. Pelseneer (**3**) ocrrected this error, but incorrectly generalises, for his group of "Elysiens"—to which both *Doto* and *Eolis* belong—that every acinus contains ova in one half and spermatozoa in the other. Trinchese (**4**) (for *Janus cristatus*), and Bergh (**5**) for *Rizzolia*, Pl. 1, Fig. 9, *Trevelyana*, Pl. 4, Fig. 10, etc.), have described the structure of hermaphrodite glands as I find it in *Doto fragilis*. Bruël (**6**) has shown in the case of *Caliphylla mediterranea* (also an *Elysien*) that each acinus is, in its young stage, lined by intermixed egg-mothercells and sperm-mothercells; that the spermatozoa begin to ripen first, and that the ova, as they increase in size, are forced in between the epithelium of the acinus and the basal-cells of the spermatids; that each old acinus has thus a peripheral layer of ova and a central mass of spermatids and spermatozoa.

In *Doto fragilis* the hermaphrodite gland is divided into a large number of units, each composed of a central chamber for the production of spermatozoa and a number of much smaller round chambers opening into the former; the smaller, peripheral chambers produce the ova. That the conditions are as above, and not so that both spermatozoa and ova are produced in the small chambers, and that the earlier developed spermatozoa are then stored in the central chamber, is proved by the fact that in the central chamber there are spermotozoa in all stages of development, as in the peripheral chambers there are ova in all stages. If we suppose that such an acinus as *Caliphylla* possesses were to be-

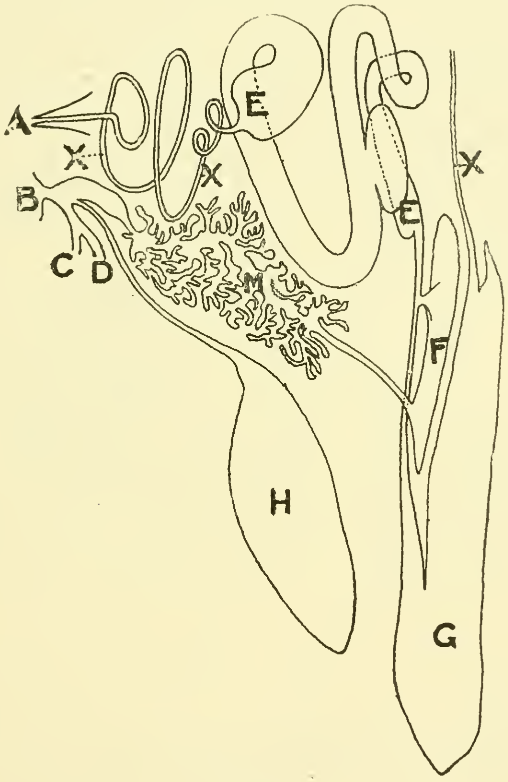

Fig. 1.

come modified so that the egg-production became localised at certain points in its wall, and that, later on, these points grew outwards to form sacs, opening into the old acinus, we readily see that the whole "unit" or grappus (central male chamber plus peripheral female chambers) of *Doto* must be homologous with a single acinus of *Caliphylla*.

The hermaphrodite gland stretches from the region of the auricles of the heart back to the hinder end of the hæmocœl; the posterior artery, by means of numerous fine branches, supplies it with blood, which drains off it into the hæmocœl. The enervation is pedal. (See my former thesis).

The peripheral sacs—ovaria—open, as mentioned above, into the central chambers, out of which runs a minute branch of the hermaphrodite duct; these branches run forwards in the centre of the reproductive mass, gradually joining up as they do so. Forwards the reproductive mass takes up less and less space until, in the region just below the auricles, there is only a broad, flat strip of reproductive tissue, with the branches of the hermaphrodite duct lying on its median-ventral surface; between this point and a point just below the ventricle the hermaphrodite duct has eight or nine branches, which are attached to the ventral wall of the pericardium. Below the ventricle the ducts all join, and the single hermaphrodite duct, so formed, at once bends downwards and to the right, after which it runs backwards along the upper, inner side of the receptaculum seminis; further back it lies along the upper, inner edge of the ampulla, into which it opens later on.

The ampulla is a large, elongated, thin-walled reservoir for spermatozoa; it lies on the right side of the body, ends blindly posteriorly, whereas, anteriorly, it is continued into the ascending part of the hermaphrodite duct. This last is a thin, ciliated tube which divides, far forwards, into two parts: the one part opens into the prostatic portion of the vas deferens, while the other opens into the oviduct by means of a small aperture, situated on a funnel-shaped papilla pointing backwards into the oviduct. One can only guess at the possible function of this curious ciliated funnel; it may perhaps serve to suck back into the vas deferens any spermatozoa which may have entered the oviduct with the ova, and so help to prevent possible self-fertilization.

The thin-walled narrow vas deferens only runs forward a short distance; at the anterior end of the pericardium it opens into the prostata, a very much coiled tube with a large lumen, lined throughout with cylindrical, non-ciliated secretory cells. It is this organ which Alder and Hancock (**2**) [Fam. 3, Pl. 4 c.] label "testicle.' The inner lining of that portion of the prostata nearest the vas deferens is raised into longitudinal folds.

The ductus ejaculatorius is a thin, much-coiled tube, lined by small, cubical, non-ciliated cells.

The penis is a stout, sharply-pointed, very muscular organ, which, in its retracted state, lies in a large chamber lined by the same kind of epithelium as that which covers the body. It is attached to the anterior, inner, dorsal wall of this chamber, and points backwards and outwards.

The oviduct is a wide tube lined with cubical, ciliated cells; from the hermaphrodite duct, it first runs backwards, then bends forwards and opens in a very large, indefinitely shaped sac with numerous outgrowths. Here, I take it, fertilisation is provided for. The fertilising chamber opens to the exterior by means of a wide tube.

The receptaculum seminis is a large, thin-walled sac opening into the vagina by means of a long, fairly wide tube. The slime gland also enters the vagina. Bruël (**6**), in the case of *Caliphylla*, is of opinion that the fertilized eggs pass through the slime gland—that there is a definite path in this organ for the eggs. I have carefully reconstructed this organ in *Doto*, and it does

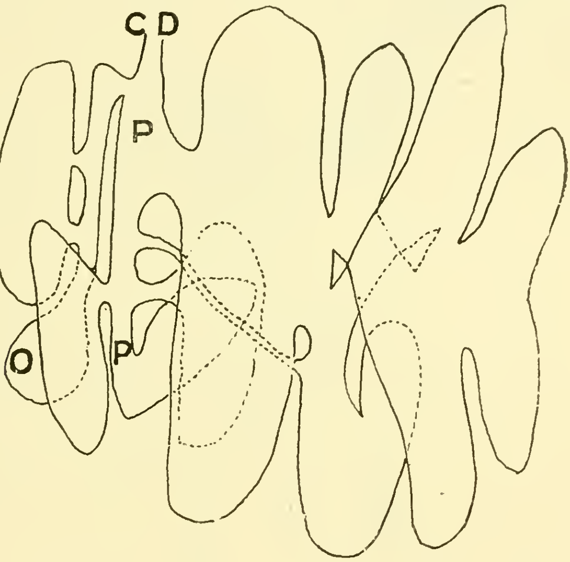

Fig. 2.

not seem probable that the eggs enter the slime gland; at least, there is no special path provided for them.* The lobes are so intertwisted and branched that I give a separate diagram of a reconstruction. The cells and the lobes of the slime gland are of the typical cylindrical type, whereas those of the two reservoirs into which the secretion is poured are flat. The ventral reservoir only has one, unbranched, secretory lobe attached to it, and may perhaps be the albumen gland [Eiweissdruse; Bruël (**6**), p. 49.] The dorsal reservoir has numerous lobes opening into it.

* See *Berghia*, p. 347.

The course of the reproductive process may be supposed to be as follows: The spermatozoa mature before the ova, and gradually collect in the ampulla; during copulation this mass of spermatozoa is transferred to the receptaculum seminis of the other copulating *Doto*. From the receptaculum the spermatozoa wander into the fertilizing chamber, and there meet the ova which have matured in the meantime; this migration of the spermatozoa will be found fully discussed by Bruëil (**6**), and, although it is questionable whether such a migration takes places in all Nudi-

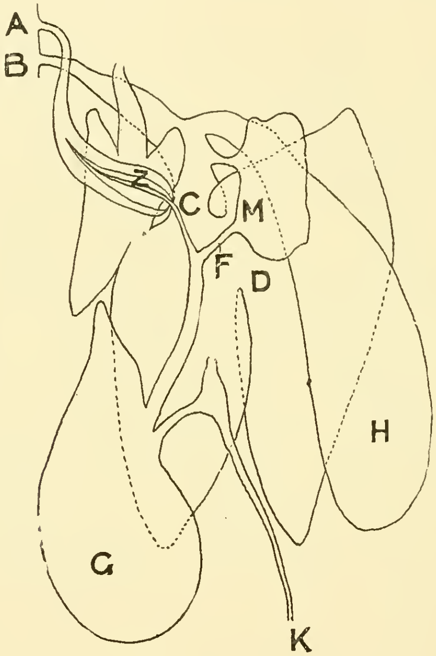

Fig. 3.

branchs, the structure of the genitalia of *Doto* makes it seem very probable for this animal. After fertilization, the eggs are passed out, receiving a coating of slime as they pass the openings of the sluice reservoirs.

Other Genera.

Other genera studied were:—*Tritonia plebeia* and *Coryphella rufibranchialis* (specimens, named from the Board of Fisheries, Plymouth); *Calma cavolinii* and *Rizzolia peregrina* (determined by myself at the Aquarium, Naples); *Berghia sp.* (from Dr. Ludwig Bruël, Halle-am-Saale).

Of these animals the *Calma* and the *Coryphella* have reproductive organs very similar to those of *Doto fragilis*.

The *Coryphella* differs only in having a very large, muscular penis, with no definite shape, and in having no ductus ejaculatorius; the fertilising chamber is small and more or less round.

The *Calma* has a penis similar to that of *Doto*, but the prostata is present simply as a thickening of the walls of the penis-chamber at the base of the penis itself; there is no ductus ejaculatorius. The fertilising chamber is a small roundish sac opening into the albumen gland, so that the fertilised eggs have to pass through a portion of that gland on their way to the

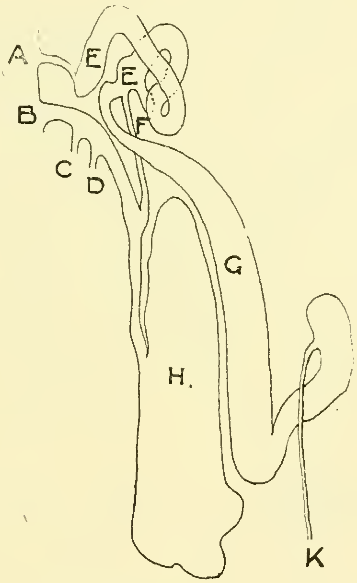

Fig. 4.

exterior. The albumen and slime glands are not supplied with reservoirs as in *Doto*.

It is not quite clear that the various sacs which I have called receptacula seminis do not at the same time act as bursæ. The anatomical structure of the organs in the case of *Doto* makes it quite possible that this could be so; even in *Calma* the receptaculum may at the same time be the bursa copulatrix, although the absence of a long ductus ejaculatorius makes it somewhat improbable. In the case of *Coryphella* it seems impossible that the thick, muscular penis, with no ductus ejaculatorius, could be introduced into the receptaculum through the long, thin tube leading into the latter.

In *Rizzolia peregrina* the reproductive organs are very different to those of the other Eolididæ studied; even *Tritonia* has organs more nearly approaching in structure those of *Calma* and *Coryphella*. The most striking modification is that there is no fertilizing chamber, and that the oviduct comes out of the prostata, so that the ova have apparently to pass through a portion of this organ on their way to the anterior. The hermaphrodite duct, almost as soon as it leaves the ampulla, swells into a gland having the structure typical to the prostata, only later on is the oviduct given off. At the apex of the blunt evertible penis is situated another gland in the form of a number of pear-

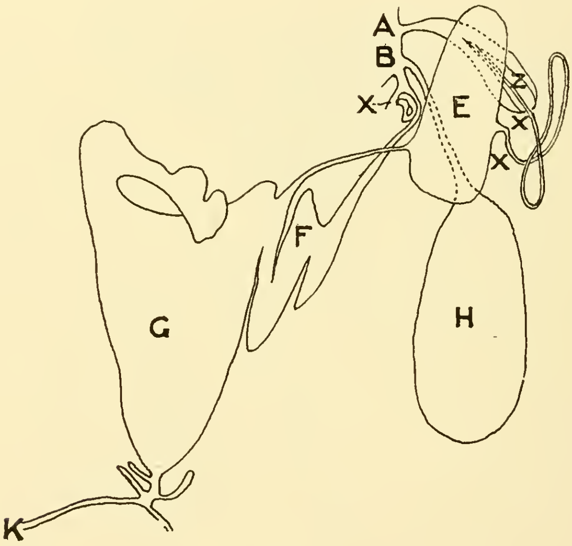

Fig. 5.

shaped glands opening into a circular chamber with a small aperture to the exterior. A feature of the structure of *Rizzolia's* organs is the absence of long ducts connecting the various reservoirs, glands, etc. The ampulla, as already mentioned, is quite closely connected to the prostata; the latter in turn runs right up to the penis; the oviduct is very short, and the receptaculum seminis opens directly into the vagina. That the organs were mature was proved by the fact that the short, broad oviduct, serving as a fertilizing chamber, was full of spermatozoa.

In *Berghia* the reproductive organs are similar to those of *Rizzolia*. The oviduct is fairly thin and long, and is filled with spermatozoa and prostatic secretion, from which it seems likely that the prostata has some influence on the migration of the spermatozoa [see Bruël (**6**)]; at any rate it is a fact that the prostatic secretion can mostly be found in at least the first part of the oviduct. In *Doto fragilis* the secretion was found round the opening of the "funnel" into the oviduct. Notice that in *Berghia* the oviduct opens into the duct between the receptaculum and the vagina. The prostata is a thick, much-coiled tube; there is no ductus ejaculatorius, and the penis is simply a thickening of the walls of the male aperture. There are two separate glands attached to the uterus; the smaller one (the albumen gland) does not stain very deeply, and has not such a high epithelium as the second (the slime gland); this latter is very voluminous, and is divided into a secretory part and a reservoir which has the form of a tube folded on itself. The two tubes run back on each other from the female opening till past the hindmost ends of their secretory lobes, and are in open connection with each other for the whole distance.* We have thus a condition similar to that described by Bruël (**6**) for *Caliphylla mediterranea,* and it is probable that in *Berghia* the eggs pass through the reservoirs of the slime gland on their way to the exterior.

Tritonia plebeia agrees with *Calma* and *Doto* in having a well-formed, pointed penis, but differs from them and resembles *Rizzolia* and *Berghia* in having no fertilizing chamber; a very broad part of the oviduct no doubt performs the function of such an organ. The oviduct is very long and coiled, and opens into the anterior end of the albumen gland, through a portion of which the eggs have apparently to pass. The prostata is a very compact, oval organ, and there is a long, coiled ductus ejaculatorius.

The species studied belong to three families, of which the Tritoniadæ is generally considered to be the most primitive, the Eolididæ intermediate, and the Dotonidæ the most highly developed. In all three families the structure of the reproductive organs is very similar, although such a condition could not have been expected, judging by the structural differences in the external genital organs. We have in each family a species (*Tritonia plebeia, Calma Cavolinii, Doto fragalis*) with a sharply-pointed penis; we have, in the Eolididæ, a species with a pointed penis and others with blunt organs; but this difference does not coincide with any modification of the female organs. True, *Calma Cavolinii* and *Doto fragilis* combine a pointed penis with a fertilizing chamber, but then *Tritonia plebeia* has a pointed penis and no such chamber, while *Coryphella rufibranchialis* has such a chamber with a blunt penis. We would at least expect to find

* The dorsal reservoir has no secretory lobes opening into it directly. These lobes lie mostly on the right side (penis side) of the animal, and open into the ventral reservoir far forwards on the left side.

a blunt penis, with no ductus ejaculatorius, in combination with a short, broad entrace to the receptaculum seminis. *Berghia* and *Coryphella* have such male organs in combination with long, thin tubes leading to the receptaculum seminis. These considerations make it probable that, in copulation, the penis is only inserted into the vagina—not into any of the ducts leading from the latter.

Summary.

Structural modifications of the reproductive organs make it probable that there is a migration of spermatozoa from the receptaculum seminis to the oviduct, along the course of which there may be a chamber specially provided for the fertilization of the ova; the the prostatic secretion plays an important part in the migration, that the penis, in many species, cannot be inserted into the receptaculum; that the eggs, at least in *Berghia*, pass through the slime gland on their way to the exterior. There are constantly present: An ampulla along the course of the hermaphrodite duct, a receptaculum seminis, a large prostata, two glands in connection with the vagina, an albumen gland, and a slime gland. The penis may be pointed or simply a thickening of the walls of the male opening; there may be a ductus ejaculatorius or not; *Rizzolia peregrina* has an additional gland opening at the apex of the penis. There is no bursa copulatrix.

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A complete list of literature on the subject will be found in (6).

EXPLANATION OF TEXT FIGURES.

Schematic representations of the reproductive organs of *Doto fragilis* (Fig. 1), *Calma cavolinii* (Fig. 3), *Berghia* (Fig. 4), *Tritoma plebeia* (Fig. 5). Fig. 2 is a representation of the slime and albumen glands of *Doto fragilis.*

A Male aperture; *B*, female aperture; *C*, entrance to slime gland; *D*, entrance to albumen gland; *E*, prostata; *F*, oviduct; *G*, ampulla; *H*, receptaculum seminis; *K*, hermaphrodite duct; *M*, fertilising chamber; *X*, ductus ejaculatorius; *Y*, entrance of oviduct into albumen gland; *Z*, penis.

Comets of 1911.—The Council of the Royal Astronomical Society, in its Report to the 92nd Annual Meeting of the Society, states that the observations of three comets seen in 1910 were prolonged into 1911. Of these, Halley's was observed at Helwan up to May 18th, and at Yerkes, Lick, and Flagstaff until the beginning of June. Metcalf's was followed up to the beginning of May, and Faye's periodic comet was seen at Algiers up to March, 1911. The number of comets discovered during the year, including the periodic comets whose positions could be indicated with more or less precision, is no less than eight. In addition, Dr. Franz of Breslau announced that on July 22nd he saw a nebulous object with a rapid motion, which he believes must have been a comet near the earth. It was of the seventh magnitude, increased three minutes in right ascension during six minutes of time, and was never seen again.

THE SEDIMENTARY ROCKS OF THE RHODESIAN PLATEAU.

By F. P. Mennell, F.G.S.

Introductory.—If we confine the term "sedimentary" to the normal deposits which have not assumed a metamorphic character, the distribution of such rocks on the Rhodesian plateau is very restricted. Most of the "high veld" is made up of very ancient metamorphic rocks, into which are intruded immense masses of granite, and in travelling about the country, one is apt to get the idea that the sediments are even less important than is really the case, for they weather so readily into loose sand that roads over them are very heavy, and they are consequently avoided as much as possible in road-making. Nevertheless, these sedimentary rocks are of considerable interest in themselves, and perhaps even more so for the light they throw on structural and physiographic problems.

Characters, etc.—The sediments with which we propose to deal in these brief notes belong to a single series almost entirely made up of sandstones, but diversified by sheets or flows of basic igneous rock. They have been aptly termed "Forest Sandstones" by Mr. A. J. C. Molyneux, who first described them in any detail, and the name of "Zambezi Series" independently suggested by myself may therefore be dropped. So distinctive are the characters of the sandstone areas, that the natives of Matabeleland give them the special name of "Gusu" (locative, e-Guswini), which is never applied to any other class of country. Their principal features are the light-coloured sandy soil, and the abundant covering of trees, usually of good size for Rhodesia, and often sufficiently close to merit the name of forest. The underlying rocks are seldom exposed, except on the slopes of basalt-capped hills or in the rare artificial excavations. In fact, even loose stones are entirely absent over large areas where the basalts do not occur. These latter conform to the bedding, or rather what is presumed to be the bedding, of the sandstones, and as they are very resistant to weathering compared with the sediments, they usually form the cappings of table-topped hills with sharp marginal slopes. Taba-z-Induna, near Bulawayo, is an excellent example on a small scale. The sandstones generally seem to be separable into a white lower and a red upper division, but the exposures are so few that it is difficult to be certain that this is of universal application. It is seldom, by the way, that more than one sheet of basalt is seen. The lower white sandstones are entirely devoid of bedding planes, and often exhibit a kind of spheroidal jointing. They are extremely fine-grained, and the grains are found under the microscope to be so well rounded that they must be regarded as wind-worn. The cement is generally chalcedonic silica or even opal (Taba-z-Induna). The red sandstones are somewhat coarser in grain, and are distinctly bedded, and indeed often flaggy. The cement is chiefly iron oxide. Paler pinkish to brownish beds also occur, and are sometimes markedly false bedded (*e.g.*, Forest Vale). The bedding is generally almost horizontal, and dips of over 5° are very rare, though at Pasipas, twelve miles north of Bulawayo, they are locally much steeper. The direction of dip is nearly always northerly, showing that the Zambezi occupies a synclinal fold. There are, it may be remarked, no extensions of the beds which occur in the Limpopo basin on to the plateau, and it is also noteworthy that even those of the Zambezi basin only stretch on to the plateau in Matabeleland, except at one point in the Charter district, which belongs physiographically to that province rather than to Mashonaland. In age these rocks are evidently younger than the coal-bearing series which is exposed by denudation to the north of the area we are considering They are, in fact, probably equivalent to part of the Stormberg beds of the Cape and Natal, and to the Bushveld sandstones of the Transvaal, that is to say, they may belong to the Jurassic period, though at one time I was inclined to rank them as possibly of Tertiary age, owing largely to the freshness of the associated volcanic rocks. The thickness of the series is difficult to estimate, as they are nowhere exposed in their normal relations with beds overlying or succeeding them in true stratigraphical sequence. It cannot, however, be many hundreds of feet, apart from the intercalated volcanics, which must often be much thicker than the whole of the associated sediments.

Volcanic Rocks.—The volcanic rocks to which we have referred occur either as isolated flows or sheets among the sandstones, which is the common mode in our area, or else as vast accumulations of unknown thickness, as in the Victoria Falls region. Though basic, they are generally fine-grained and free from olivine, being made up of labradorite laths and grains of augite. Glomeroporphyritic aggregates (or composite phenocrysts) of felspar or felspar and augite are characteristic. In most of the occurrences of the plateau there is an extraordinary uniformity in type. There is, however, an occurrence of augite andesite near the Insese River. Whether we are always dealing with lava-flows is somewhat uncertain. The rocks within a radius of forty miles from Bulawayo are seldom more than slightly vesicular, though further off there are quite scoriaceous types, which are obviously lava (*i.e.*, near the Gwai-Khami junction). Under these rocks, moreover, there may often be seen an induration of the sandstones (*e.g.*, Taba-z-Induna Esipungwene, etc.). This is not more than a few inches, or at most a foot from the junction, though it is sometimes enough to give rise to a prominent ledge on the hill slopes, and in one case (Umfazumiti) has apparently been instrumental in preserving a flat top to the hill after the removal by denudation of the basalt. When it is considered that the cement of the sandstone affected was usually opal, there is removed the principal reason we might otherwise have for regarding the alteration

Map of Forest Sandstones on the Rhodesia High Veld.

The heavy broken lines off the sandstone (shaded) areas indicate pre-Forest Sandstone ridges.

as a sign of intrusion. There is no evidence anywhere of transgression across the bedding of the sandstones, and it accordingly seems probable that even the non-vesicular basic rocks are true lava flows. Deposits of laterite often result from alteration of the lavas. They are usually highly ferruginous, and seem rarely to contain any considerable amount of alumina.

Distribution.—The various tracts of "Gusu" on the plateau are nearly always situated on the elevations forming the watersheds between the main streams, and at only one point, namely, near the Leopard road on the Vungu River, do I know of an instance in which an important watercourse is crossed, until one enters the country to the north, where no other rocks are exposed. This feature is well brought out by mapping, as will be seen from an inspection of the map on page 352. On crossing such a river as the Bembezi or Shangani, the Forest Sandstone areas present the appearance of long, heavily wooded ridges with perfectly flat tops. At a distance they have a deceptive aspect of steepness, but the slopes are usually so gentle that it is difficult in travelling to tell whether one is going up or down. There are several small outliers near Bulawayo, of which the largest is marked by the conspicuous basalt-capped hill of Taba-z-Induna, twelve miles from the town. Another is found north of Inyati Mission Station. The Somabula Forest marks a typical long strip stretching along the Gwelo-Shangani Watershed right on to the apex of the plateau south of the town of Gwelo. Its southern extremity is marked by a series of gravels and sands whose relation to the more typical forest sandstones is uncertain, though they are unquestionably younger. From them has been extracted some quantity of diamonds and other gems.

Physiography.—We have already remarked on how the narrower tracts of Forest Sandstone country are confined to the watersheds between the larger streams which run towards the Zambezi. This point, together with a consideration of the levels, is sufficient to show that the metamorphic area of the plateau represents the original plain of denudation on which the sandstones were laid down. It has only begun to be dissected by the present-day river systems, a fact which accounts for the want of striking features near Bulawayo and along the line of railway which follows almost exactly the axis of the plateau right through Matabeleland. Successions of vleis usually mark the edges of the Sandstone tracts. It is very interesting to observe that there are still certain pre-Forest Sandstone features to be discerned. There is a dolerite dyke, which illustrates this point well, which forms a long, rocky ridge by the Leopard road near the Shangani River. This disappears under the sand on the rising ground near the Vungu, but emerges quite unexpectedly as a ridge just north of that river, together with the granite in which it is intrusive. The Banded Ironstones show similar features very prominently. Thus they protrude through the sand near Ilitje, south of Taba Aikenjwe. In many places on the plateau there are great ranges of Banded Ironstone and sometimes other rocks running straight across the main streams, which have to pass through them in narrow and sometimes precipitous gorges. This puzzled me for a long time, and it only became clear on realising that the streams must have originated prior to the denudation of the sandstones, which once filled all the lower ground even when they formed only a thin capping on the ridges. Their courses were determined by the general slope before this covering was removed; hence their apparent discordance with what now seems a much more natural direction to have taken. As examples of the seemingly anomalous courses taken may be instanced the cutting through of the banded ironstone range by the Bembezi at Taba Aikenjwe, the intersection by the Gwelo River of the big ridges of Ironstone below the Do-Me-Good Mine, and the steep and narrow poorts by which the Kwekwe and Sebakwe Rivers pass through the high range of grits and conglomerates (Archæan) near their junction Much travelling over the country has convinced me that nearly all the ridges of Banded Ironstone, which are such a prominent feature of the schist areas, are probably of pre-Forest Sandstone origin, often, no doubt, with their features considerably modified or accentuated by denudation of more recent date.

EUCRANGONYX ROBERTSI, METHUEN. A BLIND CRUSTACEAN.* —A zoological discovery of unusual interest has just been described and beautifully figured by the Hon. Paul A Methuen in the Proceedings of the Zoological Society for 1911. The animal concerned is a blind crustacean originally found by the members of the Pretoria Field Naturalists Club in the water at the bottom of a small cave at Irene, near Pretoria: it was subsequently taken in the Makapan Caves. This little shrimp-like creature, now known as *Eucrangonyx robertsi,* is essentially a cave-dweller, and as such is perhaps the most typical instance actually known from South Africa; but its interest to zoologists centres round its probable origin, for, whilst the cave crustaceans must have originally come from fresh-water lakes or rivers, such lake or river forms, of these Gammarids, are no longer to be found in Africa, though they are common enough in the more temperate parts of both Northern and Southern Hemispheres. Now the genus *Eucrangonyx* is also known from wells, caves and lakes in Europe and North America, the South African species, according to Mr. Methuen, being most closely allied in structure to the species found in the wells of Bohemia.

* Annals Transvaal Museum, 1911. Notice of a Freshwater Amphipod from South Africa, by Paul A. Methuen.

In most groups of animals such facts would perhaps imply that the genus had gradually spread from some centre of origin, and had differentiated into several species as it dispersed; but in the case of such a cavernicolous creature as *Eucrangonyx* it is difficult to understand how dispersal could take place, excepting through a continuous system of subterranean passages. Mr. Methuen thinks it probable that this is a case of convergent evolution, and that, originally a normal fresh-water shrimp, it has gradually acquired a likeness to the other species of *Eucrangonyx*, as it adopted the cavernicolous habit. To explain the total disappearance of any descendant of the original gammarid stock in our surface fresh-waters, he points to the prevalence of fresh-water crabs and prawns in South Africa, and it certainly is a fact that the river crabs are most exclusive creatures, and in many parts of the world prove more than a match for crayfish. In this connection it would be interesting to know what is the evidence with regard to the antiquity of the fluviatile crabs and other crustaceans in South Africa. Mr. Methuen now states that he has found another amphipod in the Transvaal: it does not belong to the same family as the *Eucrangonyx* Though we are fairly well acquainted with the commoner crustaceans of our vleis and streams, these discoveries are enough to show that our knowledge thereon is far from complete. It is especially desirable that the cave faunas throughout South Africa should be thoroughly explored.

TRANSACTIONS OF SOCIETIES.

Geological Society of South Africa.—Monday, February 12th: Mr. H. S. Harger, President, in the chair.—"Note on the nature and origin of the Vredehoek tin deposits, Cape Town"; E. H. **Nellmapius.** The occurrence of primary tin is confined to rocks of the Malmesbury series, consisting of slates and hard quartzites, situated on the lower slopes of Devil's Peak, overlooking the city of Cape Town. The tin-bearing zone is 27 feet wide, strikes approximately north and south, and a similar deposit is being prospected on the other side of Table Valley. A very pure cassiterite, reddish or light brown in colour, and sometimes translucent, occurs, in large well-formed crystals, in the veins consisting of large interlocking white quartz grains. The vein quartz shows under the microscope numerous liquid inclusions generally containing gas bubbles The Malmesbury beds were partly shattered by eruptive action, and rendered permeable to the residual waters of the granite, which is intrusive in the Malmesbury slates: as it is recognised that tin oxide can be carried and deposited by aqueous solutions, even at ordinary temperatures, it seems probable that the mineralisation is due to deposition from magmatic waters or from aqueous solutions whose tin contents have been derived from the underlying granite.

Chemical, Metallurgical, and Mining Society of South Africa.—Saturday, February 17th: Mr. C. B. Saner, M.I.M.M., M.I.M.E., President, in the chair.—Presidential address: C. B. **Saner.** Some of the important problems of recent date in connection with Rand mining were briefly referred to, including the equipment of shafts above and below ground, the handling and transport of material, stoping and sand-filling operations, mine-ventilation and the prevention of dust, the erection of sanatoria for miners, the housing of mine employés, the establishment of Mines training schools, the supply of unskilled labour, and the improvement of native compounds.

South African Institution of Engineers.—Saturday, February 24th: Mr. F. H. Davis, President, in the chair.—"The evolution of printing and type-setting machines": A. E. **Blevins.** The paper, which was profusely illustrated, began with a brief survey of the history of printing, and then proceeded in two sections, the first of which dealt with printing machines under the following sub-heads: hand presses, platen machines, cylinder or sheet printing machines, and rotary or web machines. The second part of the paper consisted of a description of the progress effected by means of type-setting machinery.

Royal Society of South Africa.—Wednesday, March 20: Mr. S. S. Hough, F.R.S., President, in the chair.—"Bushman sticks decorated on intaglio and poker work; a note on the decorative skill of the Bush people and other aborigines": Dr. L. **Peringuey.** The poker work was probably of Kafir origin, whence the Bushmen may have obtained and improved on it. The Bushman combined the two arts of painting and graving, and were capable of executing complicated pictographs.—"Some meteorological conditions controlling nocturnal radiation": Dr. J. R. **Sutton.** The results of hourly observations of radiation temperature between sunset and midnight by means of spirit thermometers. After allowing for the state of the sky and the movement of the air, the only important factor determining radiation temperature gradient is relative humidity.—"The resultant of a set of homogeneous lineo-linear equations.": Dr. T. **Muir.** Three methods were given for obtaining the resultant, to one of which Sylvester referred in 1863, without, however, publishing what he asserted to have been the successful outcome of his researches.—"The variation in the value of the atmospheric electrical potential with the altitude": Prof. W. A. D. **Rudge.** An account of observations taken in different parts of South Africa to find the relation between atmospheric potential gradient and altitude. The potential gradient was found to vary greatly with altitude, the extreme value at 6,500 feet altitude being only one eighth that at sea level, and generally the greater the altitude the smaller the potential gradient. Johannesburg proved an exception to this, owing to the clouds of steam, and especially of the dust proceeding from the mine heaps.—"Respiration and cell energy": Prof. H. A. **Wager.** The theory that the energy required in all organic life is derived either directly or indirectly from the sun is disproved. Energy cannot be stored away to be drawn on when required. The first energy available in a cell probably comes from synthetic processes set up by the introduction of water or oxygen into the cell, and the energy set free during the union of oxygen with liberated carbon is probably the main source of all energy manifest in organic life.

NEW BOOKS.

Thomsen, Dr H.—*Deutsches Land in Afrika.* Munich: Verlag d. Deutschen Alpenzeitung. 1911. $10\frac{1}{2} \times 7\frac{1}{2}$. pp. viii, 188. Maps and illus. 16s.

Letcher, Owen.—*Big game hunting in North-Eastern Rhodesia.* London: J. Long, Ltd., 1911. $9 \times 5\frac{1}{2}$. pp. 266. Maps and illus. 12s. 6d.

Playne, Somerset.—*Cape Colony (Cape Province): its history, commerce, industries, and resources.* London: Foreign and Colonial Publishing Co., 1910-11. $12\frac{1}{2} \times 9\frac{1}{2}$. pp. 792. Maps and illus. 25s.

Hodson, Arnold W.—*Trekking the Great Thirst: travel and sport in the Kalahari Desert.* London: T. Fisher Unwin. 1912. 9×6. pp. 360. Maps and illus. 12s. 6d.

FURTHER OBSERVATIONS ON THE ORIGIN OF THE RAND BANKETS.

By Professor Ernest H. L. Schwarz, A.R.C.S., F.G.S.

(Plate 3.)

Continuing the comparison of the Witwatersrand area with that of Cape Colony,* we find a remarkable similarity in the igneous intrusions in the two areas; just as there can be traced in the sediments several recurring periods in which the same conditions on land produced the same nature of the deposits under water, so in the up-welling of liquid rocks there is a close parallelism in the Transvaal and Cape Colony in successive periods. In the Transvaal there is a great laccolite, two hundred and fifty miles in longest diameter, which occupies the Bushveld to the north of Pretoria; it is surrounded by an areole of dykes and sills which considerably increase its area. In the Cape Colony there is no central body of a laccolite apparent, but the whole of the Karroo, from Natal to the western coast nearly, is permeated by a vast number of dolerite dykes and sills which make

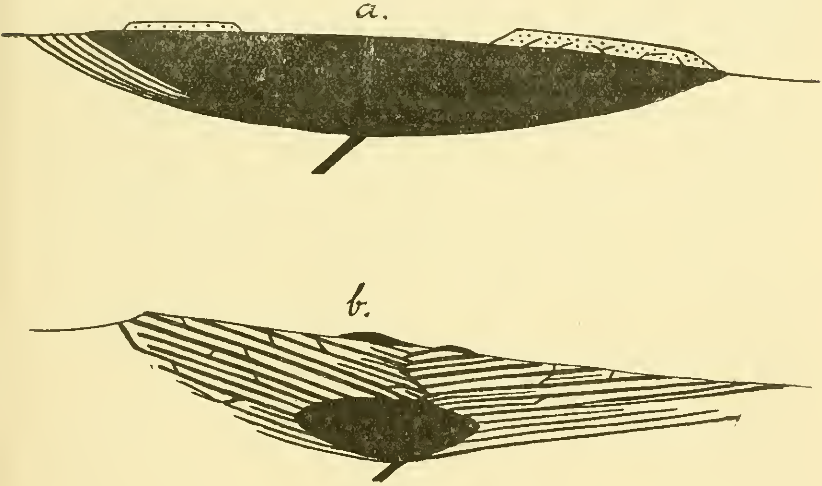


Fig. 1.

a.—The Bushveld (Transvaal) type of laccolite.
b.—The Karroo type of laccolite (cedar-tree type).

up what is known as a cedar-tree type of laccolite. It will be the purpose of this paper to describe these two laccolites. The bearing of them on the question of the title-subject of the paper is that in both cases to the south there is a vast thrust-area, which has been planed down and obscured in the Transvaal, but which in Cape Colony can still be clearly recognised in the folded

* See pages 52 to 59 of this volume.

mountains of Cape Colony, and the inference, therefore, is, that the Witwatersrand Beds have been intensely folded.

The Transvaal laccolite or, as it is often called, the igneous complex of the Bushveld, forms a solid mass of igneous rock actually 255 miles long from east to west; it is of an average of 80 miles broad, but in the centre, on the north, there is a great extension, making the total north and south length only a little shorter than the east and west one. It is composed of granite with dark red felspar; hence the frequent use of the term red granite, to indicate this rock in contrast to the older grey granite All round the rim of the main portion, excluding the northern extension, there is a broad selvage of basic rocks, principally norite. The basic rocks vary in basicity through olivine rocks to actual masses of magnetite and chromite, and the granites, also, vary in acidity to rocks composed of quartz with only a small proportion of felspar, the ultra-acid rocks. The body of the laccolite rests on the rocks of the Transvaal System, the Black Reef quartzites below, the Dolomite above, and the highly ferruginous sediments of the Pretoria Series on top. Into these latter there have been intruded a vast series of sills or dykes running concordantly with the bedding of the sedimentary rocks; these are of diabase or altered dolerite.

The arrangement of igneous rocks in this great laccolite is in accordance with similar occurrences elsewhere; that is to say, Rosenbusch's law of decreasing basicity in the order of consolidation of the minerals and the rock types composed of the minerals, is reversed. As a matter of fact, Rosenbusch's law only obtains in Plutonic masses, and then by no means universally; in masses of fluid rock crystallising under dyke conditions the basic rocks appear always at the edge, and the centre, which remained liquid long after the outside had consolidated, crystallises as acid rock. It seems possible that this differentiation in the magma is not original, but that the outer edge of the liquid mass incorporates portions of the surrounding rocks; in the present case the vast addition of lime, magnesia and iron to the liquid magma by the incorporation of the Dolomite and Pretoria Beds would seem more naturally to account for the basic and ultra-basic selvage, the more so as where the granite impinges on the siliceous lavas or the sandstones of the Waterberg, there no basic selvage makes its appearance. The intense viscosity of liquid siliceous magmas would prevent the assimilated lime, magnesia and iron salts from mixing with the more siliceous interior, and the lower melting-point of the basic rocks would cause that portion rich in these bases to crystallise readily, so that on this view the sharp demarcation between the acid centre and basic selvage can very well be explained; better, in fact, than on the magmatic segregation view.

The question arises, if the basic selvage were derived from the assimilation of the sedimentary rocks by the siliceous igneous magma, there ought to be a heterogeneous collection of products according to the varying nature of the sediments absorbed, whereas there is a fairly constant type of rock exhibited in the selvage. The answer to this is to be found in the selective action of the crystallising forces, these having the power to control the material out of which the crystals are being formed, retaining those substances which help to build up the type crystals and rejecting unsuitable substances. The action can be studied in the andalusite and cordierite rocks that have been produced as a result of contact metamorphism round the laccolite, or, in fact, in any contact zone. I first observed the facts in the andalusite schist of George.* The first indication of metamorphic action is the production of a fels or hornstone; the andalusite substance is deposited as a cement in patches throughout the sedimentary rock, and the minerals and fragments in the sediment are as yet unaltered. Gradually, as the action of metamorphism is prolonged, the andalusite dissolves the edges of the included grains, assimilates substances suitable to its growth, and passes out the unsuitable material, at the same time gradually widening its cavity and lining up its crystalline boundaries. The included fragments and grains of chlorite, mica,, quartz, etc., have now rounded edges, and are much more sparsely scattered throughout the crystal. Some substances in the sediment cannot be assimilated, and in many cases these are arranged by the crystallising forces in certain axial lines which form the dark crosses in the variety known as chiastolite; lumps of material that in the beginning were not penetrated by the andalusite substance become whittled away to little specks, and remain like cysts in the crystal.

The same laws that apply to the individual crystal apply to the collection of crystals forming the rocks, and hence the rock type grows by the absorption of sedimentary rocks, but does not lose its individuality in the process; the little cysts of undigested material in the andalusite crystals of George find their parallel in the xenoliths, or masses of sedimentary rocks included in the igneous rocks. Harker† has adduced as an argument against the theory that igneous rocks "stope" out the chambers that they occupy and assimilate the blocks that fall into the liquid mass, the fact that in Skye masses of Cambrian limestone rest as included bodies in the granite and gabbro indiscriminately. The cysts in the andalusite may very well account for these, as the xenoliths of limestone would represent kernels which escaped absorption; in the case of the granite the viscosity of the liquid enabled the limestone to withstand absorption, and in the case of the gabbro, the rock was sufficiently rich in lime to reject further additions of this material.

* "The Andalusite schist of George," Records Albany Museum, vol. ii., pt. ii., 1907.

† "Tertiary Igneous Rocks of Skye" (1904), p. 97.

Looking at the subject from another standpoint, it is inconceivable that a vast mass of igneous rock—taking it as a molten mass on the old view, or as a solution containing a corrosive acid like silica on the newer view—should flow over and rest upon a mass of ferruginous and calcareous rocks without absorbing them. Even laterally, without the aid of the pressure derived from the weight of the liquid mass, the sediments are profoundly metamorphosed and in part recrystallised: add to the metamorphic action an additional provocative of change such as an increase of pressure when the liquid mass wedged its way between the Pretoria Beds below and the Waterberg Beds above, and actually lifted up the latter, then it is inconceivable that the Pretoria and Dolomite Beds could withstand being absorbed.

The Transvaal laccolite differs from the ordinary type of small laccolite in that the vast size of the mass has caused the bottom to be convex and not a straight line, while the arching of the top, judging from the small portions of the cover still remaining, was not very pronounced. In other words, one has to turn the ordinary diagrams of laccolites of the Henry Mountain type upside down to obtain an idea of the nature of the Transvaal laccolite, and this is due to the weighting of the crust by the additional lode, and perhaps by the material from below, on being transferred to a higher horizon, leaving a hollow which caused the sedimentary beds to curve downwards; certainly the beds of the Transvaal System dip towards the laccolite all round the margin.

The crowd of sills of diabase that penetrate the sedimentary beds round the margin belong to the laccolite, and can be regarded as a *lit-par-lit* injection on a large scale. Similar occurrences have been described by Pirsson from the Judith Mountains in Montana, but these are very small in comparison with the Transvaal laccolite.

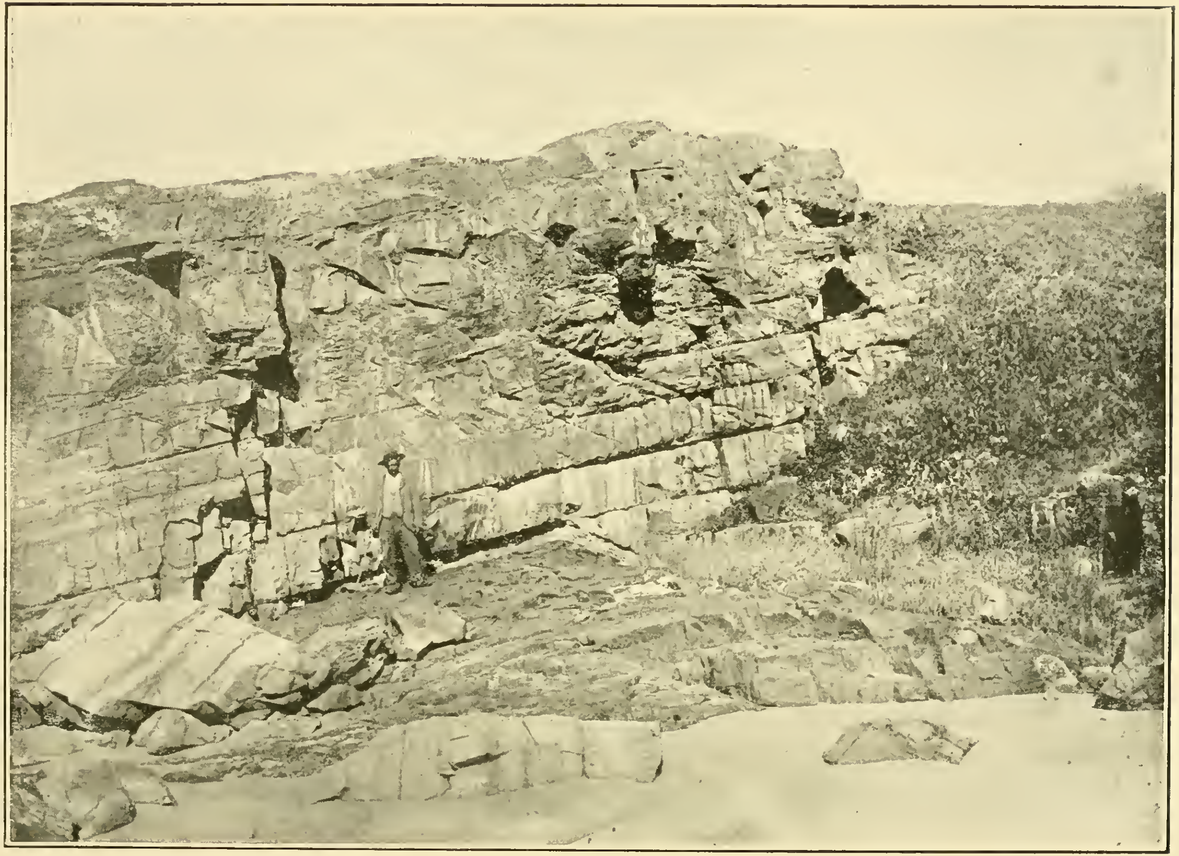
Evidences of thrusting on the south of the laccolite, and caused by the laccolite, are very plain; the Pretoria Dolomite and Black Reef Beds immediately about Pretoria run east and west, the folds being huddled up against the block of granite that has caused an obstruction. To the east, however, where the influence of the granite is not felt, the strike of the beds splays out in a very marked manner. The dykes of diabase follow strictly the strike of the sedimentary beds both in the place where they run east and west, and where they splay out to the south-east; therefore the intrusions of the sills was contemporaneous with the shifting of the strike. Although there is reason to suppose that a good deal of the sedimentary beds was absorbed by the laccolite when it was being intruded, yet the vast central area consisting of granite represents new material that has come in and occupies the space which the sedimentary beds once occupied, and, as the top of the laccolite is only slightly domed, it means that there must have been a vast lateral thrust. It appears that this thrust was only relieved on the south. Does the thrusting and folding in the Transvaal System to the south of the laccolite represent the whole of the relief requisite? It would appear to be totally inadequate. The crumpled Transvaal Beds and the granite must have been thrust bodily southwards and have affected the beds lying between the Johannesburg-Pretoria granite and the next line of granite bosses; that is to say, the beds lying between the Johannesburg-Pretoria granite and the Heidelberg and Vredefort granite bosses must have been intensely folded. The beds that now occupy that area are the Witwatersrand Beds with a layer of Transvaal Beds riding on top. The normal mapping of the Witwatersrand Beds does not take into account any folding; each successive bed of banket on the Upper Series is taken to represent a normal succession. It is true that great numbers of thrust faults occur everywhere which by themselves indicate that folding has taken place; but unless we recognise that the Witwatersrand Beds are themselves folded upon themselves, the technic geology of the country is inexplicable. We will now take the Karroo laccolite to illustrate what does occur when such a laccolite is intruded, and the effects are not yet obscured by denudation.

The Central Karroo area is perfectly plain; on the south a number of sills of dolerite appear dipping slightly inwards to the north, and on the north a similar series of sills dip in towards the south; between the two margins is an upland region, the High Karroo, about Sutherland, Fraserburg, Carnarvon, and so on, where the country is riddled with dykes and great expansions which in themselves form considerable laccolites, ten to fifteen miles in diameter. In this area the southern limit of the dolerite lies approximately along the main water-shed of the country, and the whole breadth of the laccolite is only exposed on the flat high-veld area. In the east, however, the laccolite is dissected; the main water-shed lies to the north, and the streams flowing south from it to the sea have deeply cut into the land, so that everywhere one sees stupendous hills capped with dolerite and traversed by connecting dykes. Further east, in the Drakensberg area, the same dolerite occurs; on the coast the same type of sill occurs, but under the Drakensberg, more in the centre of the laccolite, the great secondary laccolites of the Insizwa, at Mount Ayliff, Mount Currie and so forth, are found as in the west The tendency to form these subsidiary laccolites seems to be a property of the axial region of the main laccolite; one finds them from the Drakensberg plateau., through Burghersdorp, at Cradock, and so on through Sutherland to Calvinia; with the laccolitic expansion there is also a less amount of the vast sills that on the exterior margins may be followed for scores of miles, branching, connecting by dykes, and often undulating instead of maintaining a horizontal position in the strata. The eastern dolerite, beginning at Cradock, frequently has a diorite accompanying it as a second phase of intrusion. At Komgha and Kentani these form great parallel dykes which, weathering more readily than the surrounding rocks, score the land as if by a furrow; the depression of these diorite dykes is known as the Transkei Gap. The eastern dolerite, again, is characterised by a little black mica, whereas the western dolerite is frequently accompanied by quartz, granophyrically intergrown with the felspars. The difference in petrographical character, however, is not sufficient to found any argument upon.

The eastern portion of the Karroo laccolite is pierced by the Drakensberg volcanoes, whereas the western portion is pierced by a large number of volcanic chimneys containing for the most part ultra-basic lavas; such as the Kimberley and Sutherland pipes. The Transvaal laccolite is similarly pierced by the vents, as yet undiscovered, from which were poured out the volcanic ash of the Springbok Flats and the lavas of the Bushveld, which are held to be equivalent to the Cave Sandstone and Drakensberg lavas. There is something, however, about the relationship of the dolerite to the Karroo sediments which has not yet been explained; wherever one finds the Karroo sediments, there is dolerite, and this often far beyond the possible area of the Karroo laccolite. For instance, in German South-West Africa the Karroo sediments were probably formed in a separate basin altogether, yet the dolerite sills and dykes accompany the sediments. It appears as if the peculiar mud out of which the Karroo sediments are formed ran easily into a molten condition as dolerite.

The basalt of the Drakensberg is of the same composition as the Karroo dolerite, possibly because it represents the same material melted up but the fact brings in a good deal of confusion, as the lavas are traversed by dolerite dykes indistinguishable from the earlier dolerite of the great laccolite, yet clearly belonging to a subsequent date.

The dolerite belonging to the great laccolite occupies a superficial area of some 700 miles long by 200 miles broad; the individual sills are some 100 to 500 feet thick, and these, with the connecting dykes and laccolites, would, if melted up, form a ball 50 miles in diameter. Is all of this new material which has been thrust in, or is some of it, the sedimentary rocks assimilated with a proportion of original igneous rock? I think there can be no doubt that the latter is what has happened, because the dolerite sheets and dykes never show any signs of having thrust aside the rocks. A dyke a hundred feet or more in thickness may come up at a high angle and then bend over to follow the bedding plane of the sediments as a sill; now if the dolerite were entirely new material that had not melted out its cavity, there should be visible above the bend of the dyke to the sill some continuance of the crack up which the dolerite came, but there is none, as far as I have seen, in the Karroo. Dykes may occupy fault-planes.



E. H. L. Schwarz.—Origin of Rand Bankets.

as along the Kenigha River in Matatiele, but this is the exception, and in the same area there are flat-headed dykes which come up vertically and stop dead at a certain horizon, the cavity occupied by the dyke being apparently punched from beneath, as Barrois described, for the granite bosses of Brittany; yet "punched" is not a happy expression, as there is no crumbling or evidence of force having been used along the edges of the dyke-cavity. In the plate* accompanying this paper there is some apparent evidence of force, as the sedimentary beds are cracked parallel with the buried side of the laccolite, but these cracks are due to the effect of the contact; the sedimentary beds were heated and permeated by hot water at the time of the intrusion, and after the whole had cooled down the sedimentary beds contracted and left these cracks as a result. If the dolerite on which the native is standing is followed to the right, the clean way in which the sedimentary beds abut on the igneous rock leave no doubt but that the dolerite has melted out its cavity, and the complete integrity of the stratum above the laccolite shows clearly that the sedimentary rocks have not been riven asunder to let in the molten magma. If the other side of the laccolite were shown, it would be exactly the same, and there is no possible question of the dolerite having been thrust in. Occurrences such as these illustrated in the plate make one ask: Has any new material come in at all; have not the sedimentary rocks sustained a sort of spontaneous melting along certain lines and over particular areas? I cannot conceive that such should have been the case: rather the explanation lies in the fact that the molten material dissolves out the cavity it is to occupy, assimilates such substances as are suitable, and passes out such as are unsuitable. Where the latter go to is a difficult question to answer, but it is possible that if an igneous rock can follow certain lines for scores of miles, provide sufficient material to not only keep itself above the melting-point, but also to melt up and incorporate the surrounding rocks, there can also be a downward stream which carries away the waste products.

If the dolerite, then, has melted out the cavities it now occupies, there cannot be an increase in volume in the whole area traversed by the dolerite. But we have seen reason to believe that the dolerite does imply the inbringing of a certain amount of new material, so that an amount of substances dissolved from the sedimentary rocks equivalent to the amount supplied as new material by the dolerite must have gone somewhere and have there collected. The somewhere can only be below the network of dykes, and, from comparison with the Transvaal laccolite,

* Small laccolite, Mazeppa Bay, Kentani. The dark rock on which the native is standing is dolerite; the sedimentary rocks are Kentani (Beaufort) Beds with Oudenodon fossils. The sedimentary beds on the right abut on the sloping surface of the dolerite, and the stratum above the dolerite is perfectly intact, and has not been arched up by the dolerite. (Photograph by Dr. A. W. Rogers.)

which, indeed, shows a Karroo type of laccolite cut down, we infer that beneath the Karroo there is a central solid laccolite into which has been poured the more siliceous material dissolved out of the sedimentary rocks by the dolerite dykes.

To look at the matter from another standpoint. The dolerite dykes imply the inbringing of new material, and new matter thrust into the crust means that the crust must have been pushed aside. In the Karroo laccolite, as in the Transvaal one, the thrust has taken effect in the south only, and the crust has been shifted southwards. But as the volume augmentation on the level of the dolerite sills and dykes is comparatively *nil*, whereas lower down there must have been considerable addition, the major thrust would be considerably below the level of the dolerite sills and dykes; therefore, all folds produced by the great Karroo laccolite should show an inclination away from the laccolite, and such, in fact, do we find. All the main folds of the Cape coastal mountains incline towards the sea, especially where they lie huddled together inside the granite bosses of the coast belt, as may be seen in the Robinson Pass between Mossel Bay and Oudtshoorn. That there has been a thrust from the interior is proved in exactly the same way as round Pretoria, for where the line of granite bosses comes to an end at George, the folds splay out to the south-east, and the last boss of granite has itself beeen carried forwards by the movement. Could we plane off the Cape Colony to sea-level, we should find the same conditions as in the Transvaal—a great laccolite surrounded with a fringe of sills, and to the south a very thick area of quartzites in which one particular bed would be repeated again and again as in the bankets in the upper Witwatersrand Beds.

Research Grants.—Applicants for grants in aid of scientific research are asked to forward their application forms, properly filled up, not later than the 1st July, 1912, to Prof J. C. Beattie, Honorary Secretary of the Royal Society of South Africa, at the South African College, Cape Town, from whom the necessary application forms may be obtained.

Radioactivity and Molecular Structures.—At a recent meeting of the Cambridge Philosophical Society, Prof. W. A. D. Rudge, of Grey College, Bloemfontein, described some experiments made by him in the Cavendish laboratory to ascertain whether intramolecular changes occurring in the conversion of magnetic into non-magnetic nickel, and of acidic into basic iron, were accompanied by development of radioactivity The conclusions arrived at were entirely negative.

THE PRONUNCIATION OF ENGLISH.

By Prof. Arthur Stanley Kidd, M.A.

("I'm not this countryman, you may tell by my tongue, sir. They're cur'ous talkers i' this country, sir; the gentry's hard work to hunderstand 'em."—*Adam Bede.*)

The importance of the correct pronunciation of English has for the most part been overlooked by writers of text-books on the English language. This is probably due to the fact that in England itself there is a large cultured class which can secure in some degree an approximation to a correct standard of speech on the part of those who aspire to a place in good society. In the colonies, however, especially when there is a second competing language, there is no such check upon deviations from the standard, and there seems to me to be a great danger of the growth of an English pronunciation which recognises no standard at all, or one very different from that of England itself. The example of the United States is a case in point, and Australia and South Africa may in time deviate from the standard to such an extent that their English speech will be hardly understood in the Mother Country.

"We do have an appalling variety of accents in the United States," says one of Gertrude Atherton's heroines. "I have lived abroad long enough to discover that. When I am an old maid I am going to mount the platform and preach the training of the voice in childhood. I have taken a violent dislike to more than one clever American man merely because he trailed his voice through his nose. I don't mind our vices being criticised as much as our crudities."

Matthew Arnold tells us in his *Letters* that he had to alter his intonation in order to be understood in the United States.

Now it may be true that many people in the States speak with a good English accent, and that many are free from the endemic nasalisation, but the general characteristic speech of the country is not of a standard English type, and it is with the object of preventing Australia or South Africa from being also differentiated by a widespread odious peculiarity that I write this warning.

The teachers of a country may do much to maintain or create a good pronunciation, but they must set the example themselves. In a country where many teachers are not of English origin, though professedly teachers of English, they should receive a thorough instruction in correct pronunciation in their training colleges.

It is not my intention to lay stress upon the individual word, for this is the least neglected part of the subject. It is on some of the other elements of the correct pronunciation that I would lay most stress in this paper, *viz.*, upon (*a*) intonation, (*b*) liaison, (*c*) speed of utterance, (*d*) quality of voice.

INTONATION.—Professor Wyld, of Liverpool, one of the few writers who deal with Pronunciation at all fully, well says in his Historical Study of the Mother Tongue:—

"Intonation is the most difficult element in pronunciation to describe or to acquire. Vulgar speakers often affect the frequent use of compound tones to express persuasiveness, self-confidence, or good-natured cunning and sagacity. Good speakers avoid this means for the expression of these emotions, or use it very sparingly. The exaggerated use of the compound tones suggests impertinent familiarity. The Scotch peculiarity of finishing a sentence with a rising tone suggests querulousness, or cavilling, to English ears."

In South Africa there is a tendency on the part of the Dutch speakers of English to avoid any rise or fall of the voice, and the result is a sad monotony. In connection with this subject I should like to point out how important it is in a bilingual part of the Empire that Colloquial English no less than Literary English should be taught in schools, for it is only through the former that correct intonation can be properly learnt.

Nasalisation is a general tendency in new countries, and there is no satisfactory explanation to be found why this is so. Even South African Dutch has become nasalised as compared with the Dutch of Holland.

LIAISON.—The proper transition from one word to another is also something rarely emphasised in text-books, and unlike the case of the single word, the Pronouncing Dictionary is of little help here. In South Africa and, I believe, more and more in the United States the neglect of this aspect of pronunciation is resulting in the mutilation of words by erosion of their final syllables. In South Africa there is a marked tendency to end a word in a sentence with an explosion instead of with an easy glide on to the next word.

SPEED OF UTTERANCE.—There is a great difference between the lazy drawl of a northern dialect or of an affected fop and the orthodox speed of Standard English, though, of course, even in Standard English the speed depends largely on the nature of the case, *i.e.*, whether, *e.g.*, public speaking, liturgical worship, stage declamation, or colloquial use. This variety of speed according to conditions is in itself a proof of the very complicated nature of correct pronunciation, therefore of the need for its being correctly taught.

QUALITY OF VOICE.—There seems to be in South Africa a certain *timbre* or quality of voice commonly heard, especially of the male voice, which would enable a careful observer to label the speaker as a South African. There is a lack of richness or body or resonance in the voice, probably due to influence of climate. Whether such local defects can be remedied by training or not I cannot say.

THE IMPORTANCE OF CORRECT PRONUNCIATION.—In addition to the important fact that Standard English is more articulate, more easily heard than the mutterings of a dialect or than the inarticulate, clipped speech of some Americans, there are many other advantages secured by a careful study and practice of a correct pronunciation.

"Where nicety of pronunciation is not critically considered and remarked upon, the effort to be exact will tend to relax in all cases where any physical difficulty is present," says Professor Tucker. "Tongues, like governments, have a natural tendency to degeneration; we have long preserved our constitution, let us make some struggles for our language," says Dr. Johnson, who also tells us that a Pronouncing Dictionary is a poor means of attaining perfection. "When you want the word," he says, "you have not the Dictionary. It is like a man who has a sword that will not draw. It is an admirable sword, to be sure: but while your enemy is cutting your throat, you are unable to use it."

Dean Alford, in his once well-known book entitled *The Queen's English*, writes as follows:—

"Few outward indications mark a man more plainly than his habit of pronouncing his own tongue. To be accurate without being precise, distinct without being artificial, to be everywhere heard, and always understood, without noticeable effort—these are the excellencies of good pronunciation; and while they come by a happy instinctive tact to some men, others seem never able to attain them, and seldom, if they lack them, to feel their deficiency. . . . Nothing so surely stamps a man as below the mark in intelligence, self-respect, and energy, as the unfortunate habit of a misuse of the aspirate: in intelligence, because, if he were but moderately keen in perception, he would see how it marks him; in self-respect and energy, because if he had these, he would long ago have set to work and cured it."

Many of us would doubtless agree with Lord Chesterfield about the beauty and grace of good pronunciation.

"Constant experience [he writes] has shown me that great purity and elegance of style, with a graceful elocution, cover a multitude of faults, in either a speaker or a writer. For my own part, I confess (and I believe most people are of my mind) that if a speaker should ungracefully mutter or stammer out to me the sense of an angel, deformed by barbarisms and solecisms, or marked with vulgarisms, he should never speak to me a second time, if I could help it."

Finally, if English is to be, in spite of local affection for French, Dutch, Kafir, etc., as mother-tongues, the common Imperial language, the medium of Empire, it is highly important that there should be a genuine effort to aim at a homogeneous pronunciation, and for grace, beauty, ease of utterance, acoustic distinctness, no better variety of English can be found than that spoken by well-born and well-bred, cultured, non-provincial speakers of Standard English. "Let us make some struggles for our language" in this respect, as Dr. Johnson said.

THE QUESTION OF A STANDARD.—That there is no absolute standard of correct pronunciation as regards many individual words may be admitted, but that there is a standard pronunciation of English in general can hardly be disputed. The pronunciation common in the Lowlands of Scotland, that common in Sheffield or Bristol, that spoken by so-called Bi-lingual Colonists—these local or provincial pronunciation-types are not similar to one another or to the Standard. A Standard Pronunciation, comprising the question of intonation, accent or stress, liaison, speed of utterance, quality of voice, etc., in addition to the question of the individual word, does really exist, though it may be hard to define. It is a pronunciation in which more especially "all marks of particular place of birth and residence are lost and nothing appears to indicate any other habits of intercourse than with the well-bred and well-informed, wherever they may be found," or, as Chesterfield put it, a pronunciation "according to the usage of the best companies."

It is true that as regards the individual word pronunciation is always tending towards change, for language in general is ever changing. As Johnson said, "no dictionary of a living tongue ever can be perfect, since while it is hastening to publication, some words are budding, and some are falling away." But for pronunciation in the wide sense there is a Standard, and no teacher ought to be let loose in our Colonies with a raw Aberdonian or a blatant Yorkshire or a vile Cockney accent.

Laughter is also closely connected with Language, and a provincial laugh is often odious. A student can often identify a Cornishman or a Colonial by the quality of the laugh. There may be no absolute Standard for a correct English laugh, but refined speech and refined laughter should, if I may be allowed the expression, go hand in hand.

In this connection, perhaps, I may be excused for calling attention to the fact that even groaning and moaning have their peculiar characteristics. This may be illustrated from the Native Polo-player in Kipling's *The Man Who Was*.

"Colonel Sahib," said he, "that man is no Afghan, for they weep *Ai, ai*. Nor is he of Hindustan, for they weep *Oh, ho*. He weeps after the fashion of the white men, who say *Ow, ow*.

It is very sad to observe how little attention is paid at Oxford and Cambridge to the correct pronunciation of Latin and Greek. The same slovenly, unscientific, insular pronunciation is in vogue to-day as existed before an approximately correct pronunciation had been determined by philological research. I mention this because it is typical of the English attitude to literary studies, and it seems to me that there is room for the application of scientific method even in literary and linguistic work.

One difficulty in connection with the teaching of Standard English is that each teacher thinks that he himself speaks that Standard English, and would feel insulted if he were criticised. Such ideas are common not only among teachers, but also among the clergy, the military and the various professions, and even lower down in the social scale such semi-conscious conceit is not unknown.

The following dialogue from *Adam Bede* will serve to bring out this point:—

> "I dare say he'd think me a hodd talker, as you Loamshire folks allays does hany one as talks the right language."
> "The right language," said Bartle Massey contemptuously. "You're about as near the right language as a pig's squeaking is like a tune played on a key-bugle."
> "Well, I don't know," answered Mr. Casson, with an angry smile. "I should think a man as has lived among the gentry from a by, is likely to know what's the right language pretty nigh as well as a schoolmaster."

SOME DIFFICULTIES OF THE CASE.—It is a very unpleasant and unprofitable task to attack individuals on points of pronunciation, for most people are sensitive in this respect, and are generally convinced of their own perfection. I have already offended more than half the white teachers of a sub-continent by denouncing the pronunciation of the Scotch and Dutch teachers of English, and anyone taking up this crusade will suffer a like fate.

Again, even when the teachers have been converted, the speech-environment of the pupils will be against reform. However, to take one of the worst cases, the London Board Schools, if greater stress were laid in school upon correct pronunciation, the pupils would tend to become immune against infection from parents and friends. I do not wish to minimise the difficulties in the way, but merely plead for an attempt to remedy this linguistic disease. Of course, if Great Britain becomes more and more Socialistic, there will be a corresponding tendency towards uniformity of speech, for the Socialist will not tolerate "affectations" such as those of the parson or of the subaltern. Such uniformity would, however, be of a down-grade type.

CONCLUSION.—In conclusion, I must state my conviction that the American Professor Lounsbury is too optimistic when he states that

> "the forces that tend to bring about unity are now so much more powerful than those that tend to bring about diversity, and the former are so constantly gaining in strength, that deviation on any large scale between the language as spoken in Great Britain and in its Colonies, and in America, can now be looked upon as hardly possible."

The following propositions sum up my contention:—

(1) That the correct pronunciation of English as the medium of Empire is extremely important;

(2) That the teaching of such pronunciation is at present almost entirely neglected;

(3) That the first step towards reform is to train the teachers of English on sound phonetic principles;

(4) That all other means of securing an approximation to uniform pronunciation should be adopted.

Geological Correlation between South Africa and the Falkland Islands.—In volume xi of the Bulletin of the Geological Institution of the University of Upsala there appears the fourth of a series of geological publications of the Swedish expedition to Patagonia and Tierra del Fuego during the years 1907 to 1909, under the direction of Dr. C. Skottsberg. The present paper, by Thore G. Halle, deals with the geological structure and history of the Falkland Islands. The marine invertebrates collected on the islands by Darwin in 1846 were described at the time by Morris and Sharpe, who did not attempt to determine the age of the formation wherein they were found, although it has since been generally regarded as belonging to the lower Devonian. The fossils collected as a result of the Swedish expeditions were submitted to Dr. J. M. Clarke, of Albany, New York, whose report is included in Mr. Halle's paper. The material indicates, Dr. Clarke says, a highly uniform arenaceous sedimentary facies, barely differentiated in any degree, and in this regard in harmony with the succession of sediments both in the Bokkeveld beds of Cape Colony, and the various expressions of the Devonian in Southern South America. The agreement with the former is perhaps the more striking on account of the pre-eminent sandy character of the beds. There is a distinctly closer relation between the Falkland fauna and that of the Cape than of the former with the fauna of the Devonian areas in South America. The lowest group of the Falkland Devonian formation seems to present all the characteristic features of the Table Mountain series. In both cases, too, the position is below the fossiliferous series. The Bokkeveld shales and sandstones correspond to the middle fossiliferous division of the Falklands. The upper series of sandstones and quartzites in the Falkland Islands corresponds to the uppermost part of the Bokkeveld, and perhaps also to part of the Wittenberg group. To a formation occurring above the Devonian in the Falklands Halle gives the name of the Lafonian series. At the bottom of this series a tillite occurs, whose description, with very slight modifications, agrees with that of the Dwyka. A striated floor has not yet been found underneath the Lafonian boulder-beds, but the author has no doubt that such a glaciated floor may be discovered if looked for in favourable localities. It is pointed out repeatedly in the course of the paper that the Falkland Islands show a striking agreement with South Africa as regards the organic remains and the stratigraphical features of both the Devonian and the Gondwanas, and the intrusions which characterise South Africa include rocks of the same composition as the Falkland diabases. Halle considers the general striking resemblances between the geology of the two regions as worthy of note in regard to a possible direct connection of the Falklands with South Africa.

MODERN THEORIES OF HEREDITY.

By Walter T. Saxton, M.A., F.L.S.

In attempting to set forth within the limits of a single paper of limited length the ideas which underlie the two main theories, one or other of which is supported by practically all students of heredity to-day, I feel that the task is no light one. The subject is complicated by the obvious necessity of reviewing as briefly as possible the main theories which have preceded those which now hold the field.

The first of these which it is necessary for us to consider is that associated with the name of Lamarck, and which was afterwards strenuously supported by Herbert Spencer. According to Lamarck's view, the slight fluctuations which all organisms exhibit (as instanced by the fact that no two men are exactly alike in every respect) are quite unimportant in heredity, but those characters *acquired* by an organism in the course of its development (*e.g.*, strength of certain muscles through use) are those which are chiefly inherited by the offspring. I am of opinion that any sensible man, by observation of some of the more obvious facts of everyday life, would come to the same conclusion, and Herbert Spencer has collected many interesting data which are very difficult to explain on any other hypothesis.

Nevertheless Darwin, by more extended observation, aided by a number of experiments, was led to quite a different theory

It is perhaps desirable, at this point, that we should make a clear distinction between the terms "observation" and "experiment." By an "observation" I mean the record of an observed phenomenon (usually as it occurs in nature) when one or more of the conditions under which that phenomenon takes place are not under the observer's control, and are usually wholly or partly unknown. An "experiment," on the other hand, signifies the occurrence of a phenomenon (not, as a rule, in nature) under conditions which are controlled by the observer. In the ideal experiment *all* the conditions are known and controlled, but often this is impossible. To further emphasize the distinction by means of an example:—The way in which green plants obtain their organic food, from the carbon dioxide of the air, could never be determined by "observation" alone, but can be readily ascertained by "experiment."

Darwin's theory of heredity, then, was based partly on observation, and partly on experiment. It was to the effect that minute fluctuations, such as occur in all organisms, are, or tend to be, inherited by the offspring, and that "natural selection," in other words the "survival of the fit," will "fix" such variations as are advantageous, while plants or animals inheriting a variation in a contrary direction will be eliminated in the struggle for existence. Darwin appears never to have discussed Lamarck's theory in his books, and it may be assumed that, while he may not have doubted the *possibility* of acquired characters being inherited, he did not regard this as of much importance in comparison with the inheritance of small continuous fluctuations.*

In stating, as has frequently been done in the last few years, that Darwin's views are discredited by the leading students of heredity to-day, we must distinguish carefully the two assumptions involved in his theory: (1) That small continuous variations are inherited; (2) that natural selection causes survival of the fit and elimination of the unfit. I venture to doubt whether any sane scientist has ever disputed the second of these doctrines, but, as Lock in his recent book on Heredity admirably expresses it: "It does not follow that natural selection, *directing the accumulation of minute differences*, has been the method by which adapted forms have originated." Lock illustrated this remark by a reference to the well-known capacity of lizards to regenerate their tails if deprived of them by any accident. The power of regenerating tails may clearly be of service to the organism, but if the evolution of such a power is to be explained on Darwin's theory, we have to admit two remarkable suppositions: (1) That a partly regenerated tail, in every stage of the process, is useful to a lizard; and (2) that such competition exists between lizards which have lost their tails that those which could regenerate them would survive rather than the others. The first supposition is conceivable, though highly improbable, but the second is absurd, since, by the same argument, how much more would all injured lizards be exterminated in competition with uninjured ones!

Since Darwin's time the theory which has had the greatest influence on modern thought, in connection with the problems of heredity, is that brought forward nearly twenty years ago by Weismann.

Before stating the essential point of this theory, it is necessary to recall certain well-known facts in connection with the reproduction of animals and plants. In the ordinary process of

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* In Darwin's "Life and Letters," however, he makes some very disparaging remarks about Lamarck's views; I have noted the following amongst others: "Lamarck nonsense". . . . a few sentences later saying that he (Darwin) had come to "conclusions not widely different from his, though the means of change are wholly so" (*loc. cit.*, ii, 23); "veritable rubbish" (*loc. cit.*, ii, 29); "absurd though clever work" (*loc. cit.*, ii, 39).

Since this paper was written I have read Dr. Traill's paper on "Atmospheric variation as a factor in organic evolution" (see Report S.A. Association for Advancement of Science, Cape Town, 1910, pp. 290-305). While I must confess to a total inability to consider Dr. Traill's views seriously, I should like to point out that, in arguing against the possibility of the inheritance of acquired characters, he speaks of the latter as one of the essential points of "Darwinism." This is, as we have seen, not the case, though the mistake is a rather common one. Since Dr. Traill has been careful to leave the carrying out of any observation or experiment in support of his main theory to others, it is hardly worth while to waste any time in discussing the latter.

reproduction only certain cells take part, which are generally known as *germ-cells*; from these germ-cells, sometimes singly, but usually only after two cells derived from different individuals have fused together, the *embryo* is formed. The embryo eventually displays to a greater or less degree the characters of the parent or parents, and the question arises, how are the characters of the different parts of the body handed on, when only the germ-cells take part in reproduction? Darwin and his contemporaries and followers were of opinion that the germ-cells were produced by the body, and that particles from every part of the body entered into their composition. This is called the doctrine of "pangenesis."

Weismann developed a quite contrary view, namely, that the germ-cells are the important part of the organism, that the rest of the body is only as it were an offshoot from the germ-cells, and that changes in the characters of the body have no influence whatever on the germ-cells. Weismann believed that in the embryo the cells giving rise to germ-cells were, from the first, distinct from those which give rise to the rest of the body, and that the germ-cells, their ancestors and descendants, remain distinct throughout the life-history of the organism. Hence the phrase "continuity of the germ plasm," which expresses the central idea of Weismann's theory. No one doubts that, ordinarily, the germ plasm is continuous (in the sense in which the phrase is used) from one generation to another, but discussion has centred in the question whether the germ-cells may be modified or influenced by changes taking place in the body, induced by external conditions. This question resolves itself into another, which can be to some extent tested experimentally, namely: Are "acquired characters" (*i.e.*, those acquired by an individual organism as the direct result of the action of external conditions) inherited? There is not the least doubt that when this question is submitted to strict experiment the answer must be that, *so far as can be seen in a limited number of generations*, acquired characters are *not* inherited. The reservation may, however, be a very important one, since, as we know, evolution proceeds very slowly, and in nature the production of a perceptible and permanent change of characters may well take a much longer period of time than that assigned to any experiment or series of experiments such as those designed to test this question. To make the case clearer, the type of experiment which would throw light on the inheritance of acquired characters may be outlined. It is a matter of common knowledge that the same species of plant often has quite different leaf characters when grown in a dry or in a wet locality. Let us take a number of seeds from such a plant, and sow half in a wet, half in a dry locality. Allow the plants so grown to set seed, and take seed samples from each type of plant. Now choose a locality of an intermediate character, and sow two samples of seeds side by side under precisely the same conditions. Then, if acquired characters are inherited, differences may be expected between the two sets of plants, those raised from "dry" seed having a tendency to exhibit the "dry" type of leaf, and *vice versa*. As a fact, no such differences can be detected, and we must admit that if acquired characters are inherited at all, it is to a much smaller extent than is commonly supposed—so small, in fact, that direct experiment has never clearly revealed its occurrence. Facts such as these have led to a very general acceptance of Weismann's theory, the essential features of which are indicated in Fig 1, illustrating the "continuity of the germ-plasm."

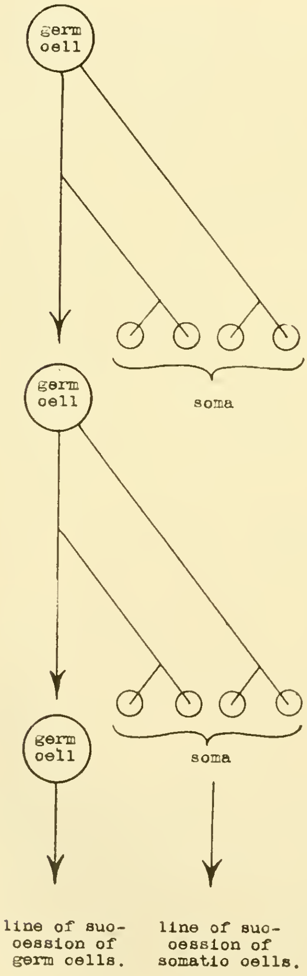

Fig. 1.

While we may admit the main idea involved in Weismann's hypothesis, it is difficult to avoid the speculation that external agencies *may* to some small extent influence the germ-cells as well as the body cells. A rigid conformity with the expectations of Weismann's theory is obviously not attained in the case of such plants as begonias, where the detached leaves are capable of giving rise to normal plants, *although containing no germ-cells nor, normally, ancestors of germ-cells.* In various plants and animals we find that almost any part of the organism in the same way may give rise to a whole new individual, *including the germ-cells.* Such facts are certainly in strong opposition to Weismann's theory, continuity of the germ-plasm not occurring in the sense in which that phrase is usually understood, and no sharp distinction being found between reproductive and somatic tissues.

With these preliminary remarks we can pass on to a consideration of the two modern views of heredity which form the main theme of my paper. As these two views, in spite of efforts to reconcile them, are in direct conflict with one another, it will be necessary to consider them separately.

I propose to deal first with the so-called *biometrical* theory based primarily on statistical methods dealing with large numbers of observations. This theory is associated with the names of Sir Francis Galton, the founder of the Eugenics Laboratory in London University, and Professor Karl Pearson. The main part of this theory is often called the "theory of ancestral contributions," and it endeavours to define the exact degree in which the characters of an organism may be correlated with those of various relations, particularly the parents, grand-parents, and great-grand-parents.

Since the statistical use of the facts may be most easily demonstrated by graphical methods, I shall first give a very simple example, quite unconnected with the subject of heredity. If we

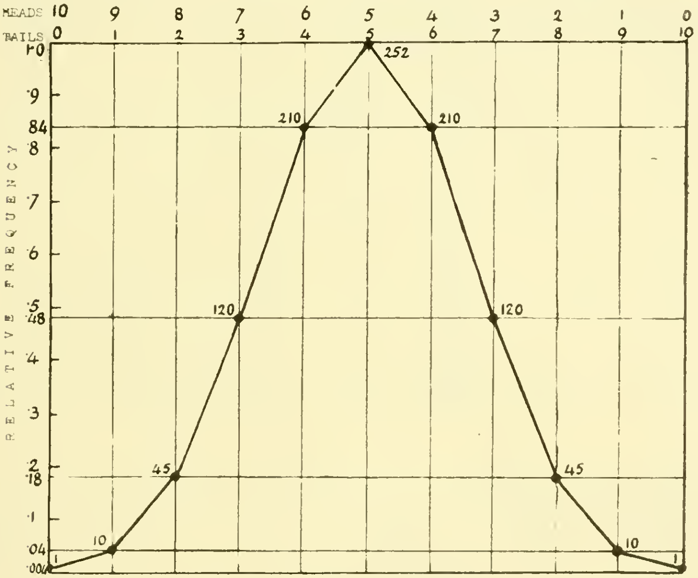

Fig. 2.

take two pennies and toss them several times, we shall find that they will come down in the proportion of: two heads and no tails, 1; one head and one tail, 2; no heads and two tails, 1. If, however, we toss ten pennies instead of two, we find that to get all of them coming down heads is a very rare occurrence, only happening about once in a thousand times. The proportions are:—

10 heads	0 tails	....	1	time
9 ,,	1 tail	....	10	times
8 ,,	2 tails	....	45	,,
7 ,,	3 ,,	....	120	,,
6 ,,	4 ,,	....	210	,,
5 ,,	5 ,,	....	252	,, etc.

We can express this as a frequency "curve," as shown in Fig. 2.

It is obviously also possible to speak of the "relative frequency" as *one* (1) for the 5 heads, 5 tails, and as decimals (*e.g.*, .84, .48, .18, .04, and .004) for the other possible combinations. The same relations may be calculated for larger numbers, *e.g.*, for 999 coins we have:—

Heads.	Tails.	Relative Frequency.
500	499	1.000
501	498	.996
505	494	.942
510	489	.803
520	479	.432
540	459	.037
560	439	.0006 etc.;

These results may also be expressed on a curve: the central part of such a curve is shown in Figure 3.

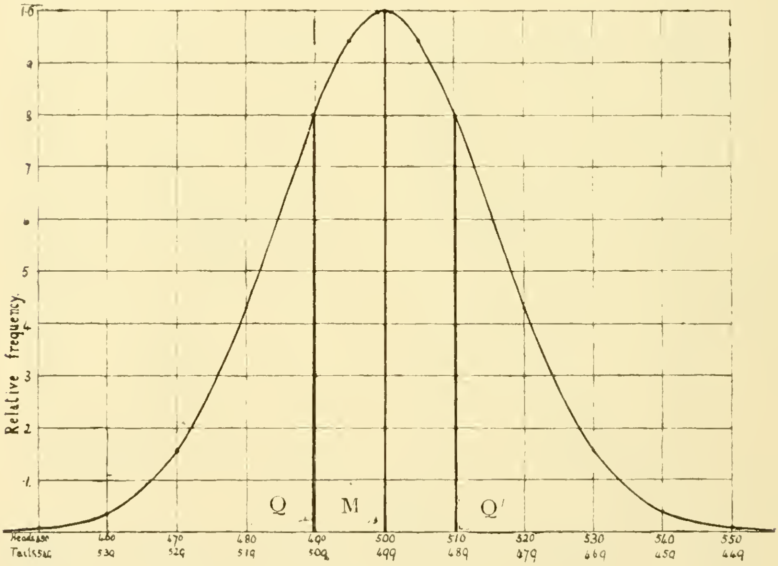

Fig. 3.

Such a curve as this is known as a "normal" curve. The longest perpendicular, M, (*i.e.*, that at the 500:499 mark) is called the "mode." If we erect a perpendicular, Q, in such a position as to divide the area to the left of M, and enclosed by the curve and its ordinates, into equal halves, then the horizontal distance from M to Q is called the "*quartile*."

Now a curve exactly similar to this may be constructed to show the way in which certain characters are distributed in a number of individuals. Take, for example, height in man. If we take a thousand men at random, and measure their heights to the nearest inch, we shall find the largest number are 69 inches high, and that the next largest numbers are 68 and 66 inches, and so on, the total range of variation being from about 62 inches to about 76 inches or a little more. The curve is shown in Fig. 4 by a continuous line with the mode (M) and the quartiles (Q and Q').

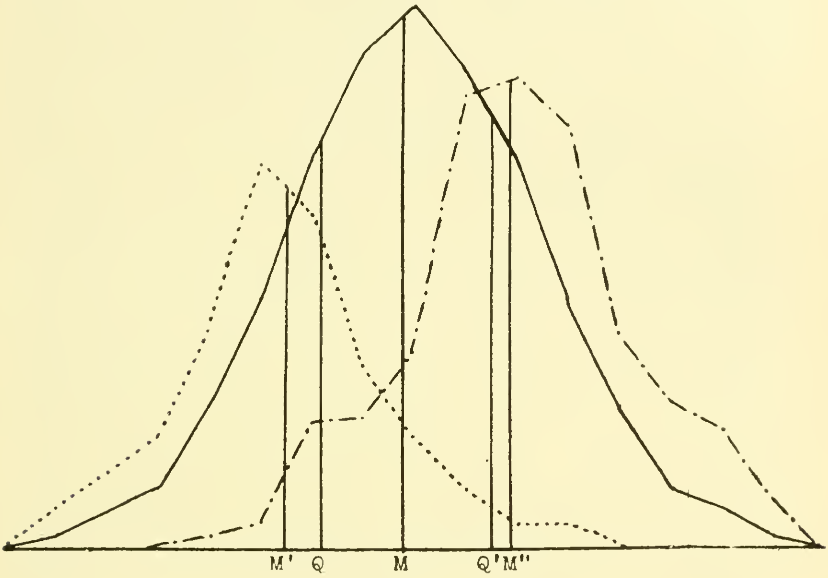

Fig. 4.

Now, since a greater degree of variability will obviously cause a *flatter curve*, it will increase the quartile, hence the quartile is a measure of the variability of a character. It is also equal to what is known as the "probable error." By this is meant that distance from the mode at which it is an even chance whether any individual shows a character value inside or outside this distance; *i.e.*, in Fig. 4, it is an even chance whether any one man's height lies between about 67 and about 70½ inches or outside of those values. The chances against the character value lying outside *twice* these limits is a little more than 4 to 1 (i.e., it is about 5½ : 1 that a man's height will lie between 65 and 72 inches). The chances against 3 times the probable error are more than 20 : 1, against 4 times, nearly 150 : 1, and for more than 4 times they are negligible.

Such curves, therefore, provide a very valuable means of dealing with statistics. Now, if the 1,000 men whose heights were measured each had one son, it will be easy to see whether height is an inherited character, and if so, to what extent. To show this we take all the sons of the fathers who were 62 inches high, and construct an exactly similar curve for their heights. The same is done for each class of fathers (*i.e.*, those 62, 63, ... inches high).* It is then found that the *mode* for the height of the sons of the fathers in any one class lies somewhere between the mode for all the fathers and the height of that class of father. For the 62-inch fathers the mode of the sons' heights will lie between 62 and 69. If it is near 62, we should say there was a high degree of *correlation*; if near 69, we should say only slight correlation was shown. Numerically, a mode of 63, 64, ... 68, inches would show $\frac{1}{7}$, $\frac{2}{7}$, $\frac{3}{7}$, . . . $\frac{6}{7}$, correlation. As a matter of fact, the correlation in such cases is found to be approximately .5. (See Fig. 4.) That between grandfather and grandson is much less, and remoter ancestors still less again.

This must suffice for an indication of the methods employed by the "biometrical" school of heredity. That the numerical relations worked out in this way do exist there can be no doubt, but whether they afford any insight into the nature of heredity is another question. My own opinion is that the information obtained is of very small value. It has become proverbial that "statistics can be made to prove anything," and it may be added that they can be applied to almost any facts capable of numerical expression. We might, for instance, measure to the nearest yard the distance between adjacent stations on the South African Railways, and plot the results in the form of a curve, from which we might deduce the mode and the probable error from the mode of any one such measurement, but the value of these figures would probably not be very large. My small opinion of the value of the method must be the excuse for a very meagre account of the attempt to formulate laws of heredity based on these statistical results. It may be added that it has been found that, on the average, the correlation for certain characters between a child and both its parents is about .5 or.6; between a child and its four grandparents it is about .2 or a little more, while it agrees with the eight preceding ancestors to the extent of about .06 to .12. It is known, however, that these relations often do not hold good.†

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* The curves for sons of fathers 64 inches and 73 inches high respectively are shown in Fig. 4 (64 inches represented by the dotted curve, and 73 inches by alternate dots and dashes).

† It is perhaps desirable to state very briefly the possible explanation of the disagreement between the results obtained by the biometrical method, and by the Mendelian method. In the latter case the most typical examples have involved single pairs of characters in comparatively simple organisms. As we shall see, however, even in some of these cases, what appear to be single characters may prove to be really made up of several interacting characters, the relation between which may be very complicated. There is evidence that in the higher animals this may be much more often the case, and that what appear simple characters in man, for instance, may in reality be complex blends of quite a large number of simple characters. Assuming that this is actually the case, and that it is impossible to distinguish the simple characters which form the complex (a very probable corollary), a

The tendency of the results obtained by these biometrical methods is to uphold Darwin's view of the importance of minute continuous fluctuations in heredity, while the theory to the consideration of which we will now proceed pays greater attention to variation of a different type. It is necessary here to explain this statement more fully. It has, since Darwin's time, been customary to conceive evolution as proceeding by the gradual addition or subtraction of a series of minute differences, this being called "continuous variation," but of late years a large amount of evidence has been brought forward, showing that in many cases variations proceed by short, but quite perceptible jumps, not smoothly and continuously. This type of variation has been named "discontinuous variation" or "mutation," and it has even been suggested that permanent hereditary changes are brought about solely by means of these mutations. The chief exponent of this view has been the eminent Dutch botanist de Vries, who has found and cultivated a number of new species of evening primrose, which have originated by mutation from the one parent species *Œnothera Lamarckiana*. This view, certainly based on some proved facts, refers primarily to the way in which variations *arise*, and we owe to *Mendel*, whose name is now familiar to every biologist, the key to the problem of how such variations are *inherited*.

Before speaking of Mendel and his work, I will describe a typical experiment of the kind associated with his name. As a plant familiar to everyone in this country, the *Mealie* may be chosen to illustrate the method employed by him. The seed of a mealie contains, besides the embryo plant, a store of nutritive material called endosperm: in some mealies this is white, in others it is yellow, and this determines the colour of the seeds. Now if we take some pollen from a mealie which bears seeds with yellow endosperm, and use it to pollinate the female flowers of a mealie which would bear white seeds, we find that the cross-pollinated flowers produce *only yellow seeds*. If the cross is

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statistical survey of the results would give very similar results to those obtained by the biometrical method. It is believed (to take a specific example) that height in man is really such a complex of characters, and that it is quite impossible to separate out the single units which go to make up the complex.

Probably the strongest experimental evidence of the truth of these remarks is to be found in some recent experiments of Johannsen's on the weights of certain kinds of seeds. Taking a definite variety of seed, and constructing a curve to show the variation in weight of individual grains, he finds a fairly constant "mode" for the seed weight. Nevertheless, by selecting definite individuals and breeding from these, he found that the "pure races" thus raised had each their own modes for the seed weight, and that this did not agree with that of the whole variety as a rule. These remarks will perhaps serve to explain why, although both the facts and the mathematics may be quite correct, the biometrical results are thought to afford very little insight into the inheritance of characters as compared with the Mendelian method about to be described.

between "white" pollen and "yellow" flowers, we still find that all the cross-bred seeds are *yellow*. We express this result shortly by stating that yellow endosperm is "dominant" over white endosperm, the latter being called "recessive." The embryos contained in such seeds are hybrids of the first generation, and are described in the notation usually employed as F1. The hybrid seeds when sown produce healthy plants and flowers, and if all the female flowers of such plants are pollinated with "white" pollen, we find approximately half the seeds produced by them are yellow and half are white. (The actual numbers in an experiment were 26,792 yellow; 26,751 white.) It should be noted that pollination with "white" pollen has *different effects* on the hybrid yellow and the parent yellow The *whites* are found to *breed true*, but the yellows behave in the same manner as the hybrids.

Parents. White (pure) × Yellow (pure)

F.1. Yellow (hybrid) × White (pure).

Yellow (hybrid) 50%, White (pure) 50%.

If instead of pollinating the hybrid yellow with "white" pollen, we allow it to be self-pollinated, we find a still more remarkable numerical relation between the offspring (described as F.2), namely, a proportion of three yellow seeds to one white seed. (The actual numbers in an experiment were 16,592 yellow; 5,681 white.) Of these, all the white breed true, but only one in three of the yellows, the remaining two-thirds giving the same results as the F.1 hybrid. We may regard the colour of the seeds as being due to the *presence or absence of a yellow pigment*.

Parents. Yellow (pure) × White (pure).

F.1. Yellow (hybrid)
(self-pollinated).

F.2.	25% Yellow (pure) (self-pollinated).	50% Yellow (hybrid) (self-pollinated).	25% White (pure) (self-pollinated).
F.3.	All Yellow.	75% Yellow 25% White.	All White.

Other characters behave in the same way, *e.g.*, starchy (smooth seed) and sugary endosperm (wrinkled seed), starchy being dominant and sugary recessive. In an experiment, 5,310 starchy (smooth) grains and 1,765 sugary (wrinkled) grains were obtained in the F.2 generation. In both these cases we have not got anything new, but if we combine the two cases just considered, that is, take parents differing from one another in *two* characters, we are able to get the two characters combined in a new way. For instance, cross a "smooth yellow" mealie with a "wrinkled white" one. F.1 is found to be "smooth yellow." In an experiment in which the hybrid was pollinated with "wrinkled white" pollen, the result was as follows:—

Smooth yellow, seeds	2,869	in the F. 2 generation.
Smooth white, seeds	2,933	
Wrinkled yellow, seeds ..	2,798	
Wrinkled white, seeds ..	2,803	

that is, approximately equal numbers of the four possible combinations are obtained, of which the second and third did not exist before in the parents. If the hybrid is self-pollinated we get in F.2 a proportion of 9 smooth yellow grains, 3 wrinkled yellow, 3 smooth white, 1 wrinkled white. All the wrinkled whites breed true, but only 1 in 9 of the smooth yellow, and 1 in 3 of the other two classes. Of the remainder, 2 of the smooth yellow are pure for the smooth character only, 2 others for the yellow character only, while 4 are hybrid in both respects; 2 wrinkled yellows give wrinkled yellow and wrinkled white; 2 smooth whites give smooth white and wrinkled white.

Gregor Mendel was born in 1822, and from 1853 to 1868 he was a teacher of natural science in Brünn (Austria), where he was a priest in the Augustine monastery. During those years he worked on cross-breeding experiments with peas and other plants. In peas he found seven pairs of characters behaving in crosses exactly as those described above in the mealie. Amongst these were:—

Smooth (dominant) and wrinkled (recessive) seeds.
Yellow (D) and green (R) cotyledons.
Grey (D) and colourless (R) testas.
Inflated (D) and soft (R) pods.
Tall (D) and dwarf (R) stems.

Mendel published the results of his experiments on peas in 1865, but they remained unknown to the world at large until 1900, when they were brought to light independently by de Vries and two other botanists. The facts first discovered by him and many similar ones have been repeatedly investigated during the last ten years, and there can be no doubt of their accuracy. There is only one theory which exactly fits these facts, and that is the one proposed by Mendel, and which, together with the facts upon which it is based, is called "Mendelism." This theory is that the germ-cells (or "gametes") which combine in reproduction can carry only one of any two mutully exclusive characters, but that the zygote produced by their union may bear both. One character, however, is usually (but by no means always) *dominant* over the other. When the gametes of the hybrids are formed each can bear only *one* of the two zygote characters, and on the ordinary laws of chance the number bearing one will be approximately equal to the number bearing the other. Since this occurs in both pollen and embryo-sac, we have, on self-pollination, equal numbers of gametes bearing the two characters mating at random, and again the result can be predicted by the laws of chance. If the characters are called A and a, we shall have the following matings occurring in equal numbers:—

A. female (♀). × A. male (♂).
A. ♀. × a. ♂.
a. ♀. × A. ♂.
and a. ♀. × a. ♂.

But as there is no difference between the hybrids Aa and aA we may write the result 25 % aa, 50 % aA, 25 % AA, the last two appearing alike owing to the dominance of A. We may illustrate the theory by placing 100 red and 100 white counters in a hat, and withdrawing them in pairs. We shall get approximately 25 all white pairs, 25 all red pairs, and 50 white and red. The phenomenon of dominance may then be illustrated by placing the red counters above the white in all the mixed pairs. Pairs of characters such as those we have been considering are known as allelomorphic pairs, or pairs of allelomorphs. Zygotes formed by the union of *like* gametes are called *homozygotes*, those formed from *unlike* gametes *heterozygotes*. The table below shows at a glance the theoretical constitution of gametes and zygotes on Mendel's hypothesis. The supposed separating out of the characters borne by the gametes at the formation of the latter is called the segregation of the allelomorphic pairs.

	A ♂	A ♂
A ♀	A.A.	A a.
a ♀	a.A.	a. a.

The above table shows the constitution of gametes and zygotes for one pair of characters. The next table indicates the same points for two pairs of allelomorphs, A,a. and B,b.

	A.B. ♂	A.b. ♂	a.B. ♂	a.b. ♂
A.B. ♀	A.B.	A.B.b.	A.a.B.	A.B.a.b.
A.b. ♀	A.B.b.	A.b.	A.B.a.b.	A.a.b.
a.B ♀	A.a.B.	A.B.a.b.	a.B.	a.B.b.
a.b. ♀	A.B.a.b.	A.a.b.	a.B.b.	a.b.

Adding up the 16 zygotes, we get A.B., A.b., a.B., a.b., 2A.a.B., 2a.B.b., 2A.a.b., 4A.a.B.b.

The last vertical line *alone* shows the result of crossing the hybrid with the recessive.

It must be emphasized that dominance is by no means an essential part of Mendelism, though it frequently occurs. Our next example is one in which there is no dominance. This is the case of "blue" Andalusian fowls, which had puzzled many generations of breeders, until it was shown to be a perfectly simple case of Mendelian inheritance. It appeared common sense to the breeders that if one continued long enough to breed from these "blue" fowls, mated with their like, one would in time get a pure breed of "blue" Andalusians. But in practice about half the offspring are invariably found to be entirely different, some black, and some white with black splashes. In every generation the breeders diligently discarded these "rogues," being most careful not to allow them to mate and so still further spoil the strain, and they bred only from the blues, but with always the same result. It has now been shown that when the white and black "rogues" are crossed *only "blues"* are hatched, these being simply the hybrids between the blacks and whites, neither being dominant. On mating the hybrids the normal proportion of one pure white, two hybrid blues, and one pure black, results.

As an example from the plant kingdom we may take the case of two species of primula (*P. sinensis* and *P. stellata*), which, when hybridized, give a distinct hybrid form which has been named *P. pyramidalis.* This on self-pollination gives the usual proportion of one *P. sinensis*: two *P. pyramidalis*: one *P. stellata*, in F.2.

These are perfectly simple examples of Mendelian inheritance, but some cases are not so straightforward as these. In some plants it has been found that an affinity seems to exist between allelomorphs belonging to different pairs, such that, instead of every possible combination of characters being found in the usual proportions in F.2, certain combinations occur more frequently than in those cases we have been considering. This is spoken of as "gametic coupling," and it has been shown, in the case of some such allelomorphic pairs, that numbers in F.2, calculated on the assumption that instead of the gametes segregating in the proportion of 1.A.B.: 1.A.b.: 1.a.B.: 1.a.b., we have 7.A.B.: 1.A.b.: 1.a.B.: 7.a.b., agree very closely with observation. (Other examples give numbers approximating to a 15: 1: 1: 15 basis.) An example of this is found in certain sweet-peas. In this case two of the allelomorphic pairs involved are purple (D) and red colours, and long (D) and round pollen-grains. Here we find that in F.2, considering the two pairs separately, we have the normal ratios of 3 purple: 1 red, and 3 long: 1 round, but if we examine the pollen *of the purple only* we find a much larger proportion of long grains, *viz.*, 12: 1, while in the reds the proportion of longs is only 1: 3.2. Combining the two, we find that the proportions in F.2 are approximately as follows (actual numbers in brackets):—

Purple flower and long pollen	177	(1528)	instead of	9
Purple flower and round pollen	15	(106)		3
Red flower and long pollen	15	(117)		3
Red flower and round pollen	49	(381)		1

In other cases of Mendelian inheritance we meet with the remarkable phenomenon usually called "reversion," or sometimes "latency of characters." This may be best explained by an example, and two varieties of sweet-pea will again be used. These are two which differ in the colour of the seed-coat, one being *grey*, and the other colourless (or *white*) F.1 showed a testa with purple dots on a grey ground (*purple*) F.2 showed a proportion of 9 purple: 3 grey: 4 white. The explanation is that there are two pairs of allelomorphs—(1) purple and its absence; (2) grey and its absence. But purple is apparently unable to appear without grey, hence:—

$$9\left\{\begin{matrix}\text{purple}\\ \text{grey}\end{matrix}\right\}:3\left\{\begin{matrix}\text{no purple}\\ \text{grey}\end{matrix}\right\}:3\left\{\begin{matrix}\text{purple}\\ \text{no grey}\end{matrix}\right\}:1\left\{\begin{matrix}\text{no purple}\\ \text{no grey}\end{matrix}\right\}$$

appears as above, since $\left\{\begin{matrix}\text{purple}\\ \text{no grey}\end{matrix}\right\}$ equals white. It is evident that the original "white" parent was really $\left\{\begin{matrix}\text{purple}\\ \text{no grey}\end{matrix}\right\}$.

A second example where *two* latent characters give rise to a new character is furnished by the sweet-pea known as "Emily Henderson." This is found to exist in two forms only differing in the shape of the pollen-grains, which are "long" (D) or "round." The flowers are pure white in both cases. F.1 has flowers with a purple standard and blue wings (the type known as "Purple invincible"). F.2 (from self-pollinated F.1) shows the following proportions:—

"Purple invincibles"	81	or	3	or	3	9
"Picotee"	27		1			
"Painted lady"	27	or	3		1	
"Tinged white"	9		1			
"White"	112					7

"Painted lady" has a red standard and white wings; "Picotee" and "Tinged white" appear as "diluted" forms of the Purple invincible and "Painted lady" respectively. The latter are dominant over the former, owing to the presence of a "strengthening" factor which we may call S. *All the coloured forms* are due to the meeting of two dominant factors which may be called X and Y, one borne by one parent and one by the other. This gives the ratio 9XY : 3Xy : 3xY : 1xy; that is, 9 coloured : 3 + 3 + 1 white. To explain the two primary colours we require a fourth pair of allelomorphs, namely, a "purple" factor P, and its absence. Thus PXY gives purple flowers, but pXY gives red flowers. The relation between the shape of the pollen grains and the purple and red flowers has already been described, as an example of "gametic coupling." This last example is one of the most complex of those worked out by the Mendelian school, and has been chosen as one which appears at first sight to be quite of a different nature. Very few cases of heredity in hybrids, however, have been definitely proved to be non-Mendelian.

One of the recent developments of Mendelism is the idea that *sex* may be a hereditary character, inherited according to Mendelian laws. Owing to the nature of the case, the inheritance of sex cannot be investigated in the ordinary manner, but quite a number of carefully devised experiments have now been carried out, most of which indicate that females are really heterozygotes in which femaleness is dominant and maleness recessive, while males are homozygous recessives. This, at any rate, explains the approximate equality of males and females, since all the male gametes bear only the male character, while equal numbers of "male" and "female" gametes (*i.e.*, gametes bearing the characters of "maleness" and "femaleness" respectively) are produced by the female. These, then, mating at random, will produce equal numbers of heterozygotes (females) and homozygous males. It would take too long to explain the experiments on which this idea is based.

It is known that some diseases and certain peculiarities in man are inherited according to Mendelian laws—as, for instance, colour blindness and red hair—but the difficulty of collecting data and the impossibility of experiment have made progress in this direction very slow.

In another direction Mendelian experiments have given exceedingly valuable practical results, namely, in the breeding of *wheats* which combine many useful characters. By the use of Mendelian methods we can choose almost any characters occurring in different varieties of wheats and combine these in one breed. Two of the most important of these are "strength" (a quality very important in baking the flour), which is dominant over "weakness," and immunity to the attacks of "rust," which is recessive to susceptibility. By the introduction of an immune parent, the immune character can be combined with almost any other desirable characters existing in a susceptible wheat, and the type thus built up may be "strengthened" by the aid of crossing with a "strong" parent. Similar experimental breedings have been carried out with other plants.

TRANSACTIONS OF SOCIETIES.

South African Institution of Engineers.—Saturday, March 9th: Mr. F. H. Davis, President in the chair.—"Loss due to impact in Californian stamps": A. S. **Ostreicher.** The author had investigated the impact between cam and tappet by the work due to deformation. Equations were given for determining the limiting values of percentage loss.

Chemical, Metallurgical, and Mining Society of South Africa.—Saturday, March 16th: Mr. W. R. Dowling, M.I.M.M., Vice-President, in the chair.—"The Luminator purification treatment of water for steam boilers": W. **Cullen.** The treatment consists in running the water over aluminium plates under certain conditions. This prevents scaling and loosens any scale previously formed. The author had tried the method for fifteen months with two 25 h.p. boilers, using about 3,000 gallons of water per twenty-four hours, and characterised the improvement noticed at first as remarkable and striking, though subsequently it was less marked. Before the application of the aluminium launders so much adherent scale used to be formed that the boilers needed cleaning every three or four weeks. The first result of this treatment was to loosen what scale there had been formed and render it capable of being blown off. The scale subsequently formed was much less than usual and easily removable. The author was unable to explain the underlying principle.

Geological Society of South Africa.—Monday, March 18th: Mr. H. S. Harger, President, in the chair.—"The Palabora plutonic complex of the Low country, and its relationship to the pegmatites of the Leydsdorp mica fields:" A. L. **Hall.** A considerable area, south of the Murchison Range, is covered by a group of plutonic rocks intrusive into the older granite. This group—the Palabora plutonic complex—is made up of a genetically connected series of massive granites, syenites, and pyroxenites. Its age cannot be definitely fixed, but its intrusion probably belongs to a period intermediate between the older granite and the Bushveld igneous rocks. A large number of coarse quartz-albite-pegmatites are associated with the margin of the complex, and probably represent its residual motherliquor, but have no connection with the older granite.—"The crystalline metamorphic limestone of Lulukop, and its relationship to the Palabora plutonic complex:" A. L. **Hall.** The intrus ion of the Palabora complex was accompanied by pronounced contact metamorphism, particularly on the limestone of Lulukop. The latter, especially at the Guide Copper Mine, contains admixtures of igneous material, represented by pyroxene and orthoclase. A large mass of the limestone had evidently been caught up by the invading magma and intensely altered.

Institution of Electrical Engineers.—Wednesday, April 10th: Mr. W. F. Long, President of local section, in the chair.—Presidential address: W. F. **Long.** A review was given of the electrical industry in the Cape Peninsula since its inception in 1882, by a private company, which was bought up by the Table Bay Harbour Board in 1886. The Harbour Board then took over the lighting of the Houses of Parliament, the electricity for which had been supplied since 1885 by a special steam driven generator. The Harbour Board plant also supplied the Cape Town Railway Station with energy until 1889, when the Railway Electrical Department was inaugurated, electrical train lighting being then for the first time undertaken. Public supply of electricity in the City of Cape Town was not started until 1895, several years later than in the southern suburbs. The first Central Station, near the Molteno Reservoir, was then opened. The present Central Power Station in the Dock Road was opened in 1904. There are at present seven central stations between the docks and Kalk Bay. Great changes were about to take place and the Dock Road Power Station would increase its output from six million units during 1912 to nine millions during 1913.

Cape Chemical Society.—Friday, April 19th: Dr. C. F. Juritz, M.A., F.I.C., President, in the chair.—"Investigation of chemical problems in a new country" (Presidential address): Dr. C. F. **Juritz.** Chemistry bears a constant and intimate relation to every aspect of individual and social life, and needs patience and promptitude in dealing with its various aspects. To direct the course of enquiry men of efficient chemical vision and the best brain power were needed. The author referred to the position of chemical research in England, America, and Australia, contrasting therewith the position in South Africa, where chemical research was almost impracticable except with respect to agricuture. In the latter there was a wide field, but euphemism with regard to the work done thereon was apt to distort the view: to attain success co-ordination of effort and unity of plan were necessary. The Bureau of Chemistry of the United States Department of Agriculture was cited as an example of this.

Royal Society of South Africa.—Wednesday, April 17th: S. S. Hough, M.A., F.R.S., President, in the chair.—"Some recent improvements in transit observing" (Presidential Address): S. S. **Hough.** The address was intended to illustrate how, in connection with meridian observing, personal errors of Right Ascension observations could be eliminated. In connection with the new transit circle of the Cape Observatory, the erection whereof was begun in 1901, Repsold's single moving web system of observing had been introduced, in conjunction with a mechanical method of driving the moving wire at a speed capable of adjustment to correspond with that of the moving star in the telescopic field. During 1911 comparative observations were made systematically by seven observers, and as a result the author stated his conclusion that practically the problem of the elimination of personal errors had been solved, all observations having been made by means of an equal number of transits in each direction, right to left and left to right, the outstanding personal discordances being of a scarcely detectable character.

Wednesday, May 15th: L. Peringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"A revision of the genus *Alepidea*, Delaroche": R. **Dummer** Twenty-three known species of the genus were described, eleven being new.—"Positive electrical change in isolated nerve": Prof. W. A. **Jolly.** The theories regarding causation of positive electrical change in isolated nerve are critically discussed, and the results obtained by different instruments and methods of investigation correlated. The positive after-variation is differentiated from positive change produced during a period of stimulation, and regarded as depending on two factors: (1) A process occurring in the uninjured part of the nerves subsequent to excitation, and (2) increase in demarcation current.—"Note on the occurrence of a leucocytozoon infection—host—the ostrich": J. **Walker.** The author proposes to name the parasite *Leucocytozoon struthionis,* and describes its microscopical appearance in stained blood smears collected from sick ostrich chicks on a farm in Middelburg, Cape Province.—"Valency and chemical affinity": Dr. J. **Moir.** The author had previously shown that atomic weights could be fairly exactly calculated by assuming a proton of atomic weight .009. It is now suggested that this proton may be the true cause of valency and chemical combination. Practically identical values of this proton are given by the three most exact determinations of molecular ratios that the author is acquainted with.—"A new species of Trygon from South Africa": Prof J. D. F. **Gilchrist.** Three species of Trygon (Sting ray) from South African waters had been recorded. The author described a fourth—apparently a new species.

NEW BOOK.

Lyell, D. D.—*Nyasaland for the Hunter and Settler.* 8vo. (9 × 5½ in.) pp. xii, 104. Map and illus. London: Horace Cox, 1912. 14 oz. 5s.

ADDRESSES WANTED.

The Assistant General Secretary (P.O. Box 1497, Cape Town) would be glad to receive the correct addresses of the following members, whose last-known addresses are given below:—

Aspland, C. Hatton, Witwatersrand Deep, Ltd., P.O. Box 5, Knight's, Transvaal.
Barton, Ernest Mortlock, Director of Works Department, Simonstown, Cape.
Boulton, H. C., c/o Messrs. Pauling and Co., Ltd., Broken Hill, Rhodesia.
Brown, Walter Bruce, c/o Engineer-in-Chief, S.A. Railways, Cape Town.
Champion, Ivor Edward, P.O. Roberts Heights, Pretoria.
Collie, J., Craigwan, Park Road, Bloemfontein.
Court, S. E., c/o Royal Statistical Socety, London.
Crockett, John, 10, Transvaal Bank Buldings, Johannesburg.
Dickie, Andrew, 475, Currie Road, Durban, Natal.
Durham, James, Consolidated Gold Fields Office, London.
Fricker, Robert G., P.O. Box 498, Johannesburg.
Leech, Dr. John Richard, 4th Avenue, Melville, Johannesburg.
Legg, William Andrew, M.I.C.E., P.O. Box 1621, Cape Town.
Macfarlane, Donald, M.I.C.E., H.M. Naval Dockyard, Simonstown, Cape.
Mirrilees, W. J., 9, London Chambers, Durban, Natal.
Nicholas, W. H., Durban High School, Durban, Natal.
Nicolson, J. Greg, Leliefontein, Government School, P.O. Carolina, Transvaal.
Preston, James, 89, Arnold Road, Observatory, near Cape Town.
Skeels, C. S., B.A., c/o Mr. Skeels, Explosives Office, Johannesburg.
Southwell, Miss Jessie, 270, Visagie Street, Pretoria.
Spengel, H., P.O. Box 3498, Johannesburg.
Teasdale, Miss E. L., Government School, Maraisburg, Transvaal.
Van Oordt, J. F., B.A., Harrismith, O.F.S.
Waldron, Frank William, A.M.I.C.E., Parliament Street, Cape Town.

A MINERAL SURVEY OF THE ZINC AND LEAD DEPOSITS OF BROKEN HILL, NORTHERN RHODESIA.

By Arthur E. V. Zealley, A.R.C.S., F.G.S.

(Plate 4.)

I. Introduction.

To the mineralogist there can be very few localities in the world of such interest as Broken Hill in Northern Rhodesia. The minerals occurring there in the deposits of zinc, lead and vanadium have attracted considerable attention in spite of the inaccessibility of the locality, which is some 300 miles north of the Zambesi. The variety and the extreme beauty, together with the rarity of several of the minerals occurring in the deposit, render its study immensely attractive, and the unique association of mineralized bones, the implements and other evidences of human occupation of the caves in the deposit further increase the interest of the subject. The deposits have been opened up for mining.

The minerals in the mines and the materials affording evidence of occupation of the caves by man and by beast have been carefully collected from time to time by Mr. Franklin White, Mr. J. L. Popham, Mr. P. C. Tarbutt, and others, and it is chiefly to these gentlemen that we are indebted for the beautiful mineral specimens from Broken Hill which are now to be seen in the museums of almost every country.

The minerals have been identified and fully described by Mr. L. J. Spencer (**1**) of the British Museum, South Kensington.

The mine, its surroundings and the cave have been described by Mr. Franklin White (**2**), who has discovered evidences of its occupation by man; further evidences—worked and carved bone, clinker, etc.—being described by the same author (**3**).

The fossil mammalian and other bones have been described by Mr. E. C. Chubb (**4**), and by Messrs. F. P. Mennell and E. C. Chubb (**5**).

The ores of lead, vanadium, and zinc were briefly mentioned by the present writer (**6**).

The examination of the minerals *in situ* and survey of their distribution bring out several points of interest regarding their origin. The mining operations carried out by the Rhodesia Broken Hill Development Co. enabled the writer to make during a visit to the mine extending over some ten days a somewhat hasty but detailed survey of the deposits, and he has thought that it may be of interest to publish the results.

Acknowledgments are gratefully made to the following companies and gentlemen who kindly gave the writer permission to examine the mines, and assisted him in various ways during his investigations:—Messrs. Percy Tarbutt and Co., The Bechuanaland Exploration Co., Messrs. A. M. Bentley, J. Blackie,

H. U. Moffat, J. L. Popham, J. Teagle, and Franklin White. To Mr. H. S. McVey the writer is indebted for drawing the diagrams which accompany this note. The photographs were kindly lent for reproduction by Mr. Franklin White.

II. Geology of the Deposits.

The country in which the deposits are situated is fairly flat except for a series of small kopjes (named Nos. 1, 2, 3, 4) and one or two others. These kopjes consist, in some instances entirely, and in others in large part, of the oxidised compounds of zinc and lead and iron.* (See Plate 4, upper photograph.)†

The mining development work carried out consists‡ chiefly several directions and at several levels; from these are put out a number of cross-cuts. A few rises between the levels and several small winzes exist, also, several shafts are sunk from the surface of the kopjes and between them; in the kopjes several large quarries and benches have been made. In Kopje No. 1 an incline passes down to water-level, where a drive exists, and from the drive which extends from end to end of the kopje two cross-cuts are made; one of these opens into the lower part of the bone cave. Nearly all the workings, therefore, are in the oxidized zone, which has thereby been particularly well exposed.

The accompanying geological sketch-map (Fig. 1) is very rough, but serves to give a general idea of the geology. The rocks appear to be highly inclined or vertical and to be striking about east and west.

In making a traverse from south to north the following rocks are observed:—

(*a*) Limestone.
(*b*) Phyllite (disturbed and contorted in places), passing insensibly to
(*c*) Limestone (largely dolomitic).§
(*d*) Conglomerate.
(*e*) ?Phyllitic grit.

The rocks are members of an ancient schistose sedimentary group, perhaps of the same general age as those occurring in Matabeleland, but probably considerably younger.

No. 1 Kopje is situated on the limestone (*c*), and near it are the smaller kopjes 3, 4 etc. No. 2 Kopje is situated alone about half a mile S.S.E. of No. 1, partly in the limestone (*a*) and partly in the phyllite (*b*).

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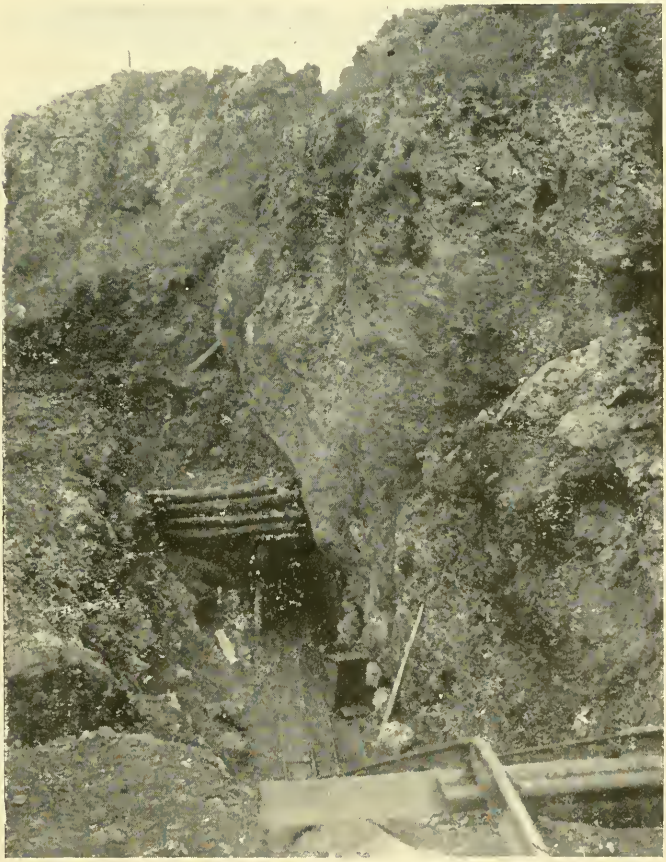
* White, *loc. cit.*, vol. vii., p. 14.

† The upper (smaller) photograph is a view of "Kopje No. 1"; the gossan of a deposit, containing the bone cave. The lower (larger) photograph is a view of the east side of that kopje, shewing the cavernous nature of surface ore, and position of a bone deposit (left-hand lower corner of photograph) at the east end of water-level drive.

‡ White, *loc. cit.*, vol. vii., pp. 14-18.

§ Mennell and Chubb, *loc. cit.*, p. 445.



A. E. V. ZEALLEY,—A Mineral Survey of the Zinc and Lead Deposits of Broken Hill, Northern Rhodesia.

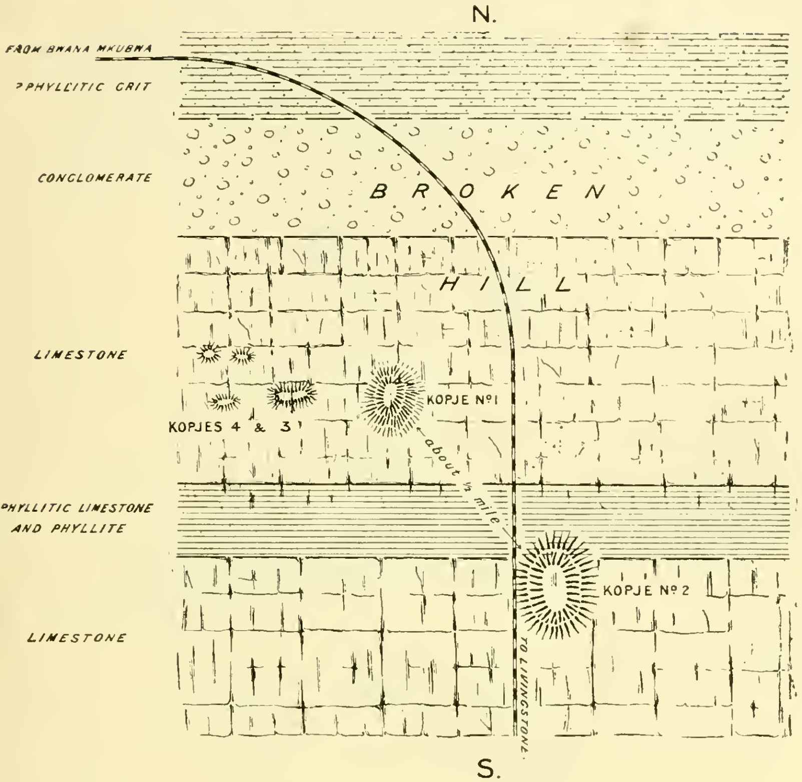


Fig. 1.
Rough Geological Sketch-Map of Broken Hill.

III. The Deposits.

The distribution and association of the minerals are of particular interest. Taking Kopje No. 1 as being the clearest example and best exposed, the distribution may be diagrammatically represented as follows (see Fig. 2):—

Zone 1.—The sulphide zone (occurring below water-level). This consists of a hard crystalline limestone, fine-grained, dolomitic and quartzose, usually considerably jointed, prevalently grey in colour, and containing scattered patches, particles and small veins of zinc blende, galena and a little pyrite. The water-level is very near the surface—some 17 feet below the general level of the surrounding country.

Zone 2.—The gossan or oxidized ore. A highly ferruginized and silicified limestone, rotted and cavernous (see Plate 4, lower photograph) and very strongly impregnated with carbonate of lead (and to a lesser extent carbonate of zinc), silicate of zinc, and the other oxidized zinc and lead minerals. This zone extends from the water-level to the top of the kopje, which is about 50 feet high. Small patches of unaltered crystalline limestone remain in this pale brown rock. This zone (2) comprises at its base—

Zone 2a—the phosphate-vanadate zone, which occupies the lower part of the oxidized portion, and consists of carbonates and silicates, etc., mixed with phosphates and vanadates. It is an irregular zone, in which the phosphates and vanadates are locally much more abundant than the other oxidized minerals. Presumably the pre-existent carbonates of zinc and lead have reacted with phosphoric acid supplied by the extensive deposits

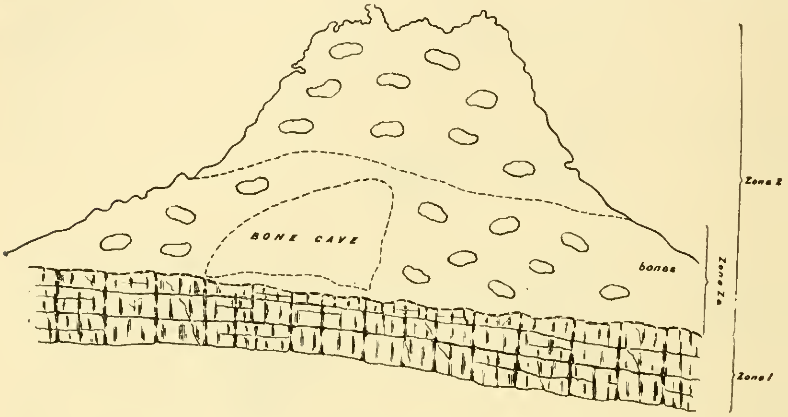


Fig. 2.

Diagrammatic Section across "Kopje No. 1,"

Shewing disposition of Mineral Groups.

2 = Carbonate-silicate zone
(2a = Phosphate-vanadate zone) } Oxidized zone.
1 = Sulphide zone

of animal remains situated in this zone to produce the phosphates of zinc and lead. The cave, which is situated in this zone, contains a considerable thickness of mineralized bone-breccia. Other accumulations of bone-breccia have been discovered in various parts of this zone; the positions of these are indicated in Fig. 3 (*a*) and (*b*).

The upper part of zone 2 consists mainly of carbonate of lead, silicate of zinc, oxide of iron, and carbonate of zinc. No phosphates or vanadates are present.

The zones are fairly well marked, but a small amount of galena was noted in the oxidized zone, and even on the surface of the kopje. In one instance a very small amount of pyromorphite was found on the surface of the kopje at its summit.

IV. Mode of Occurrence of the Minerals.

The details of the occurrence of the minerals are given briefly hereunder:—

Galena and Blende occur mainly below the water-level, where exploited in Kopje No. 1, in small but frequent dissemination and veinlets in the limestone. These veins are generally not more than an inch or so wide. No sulphide minerals have been exposed in Kopje No. 2, where work has

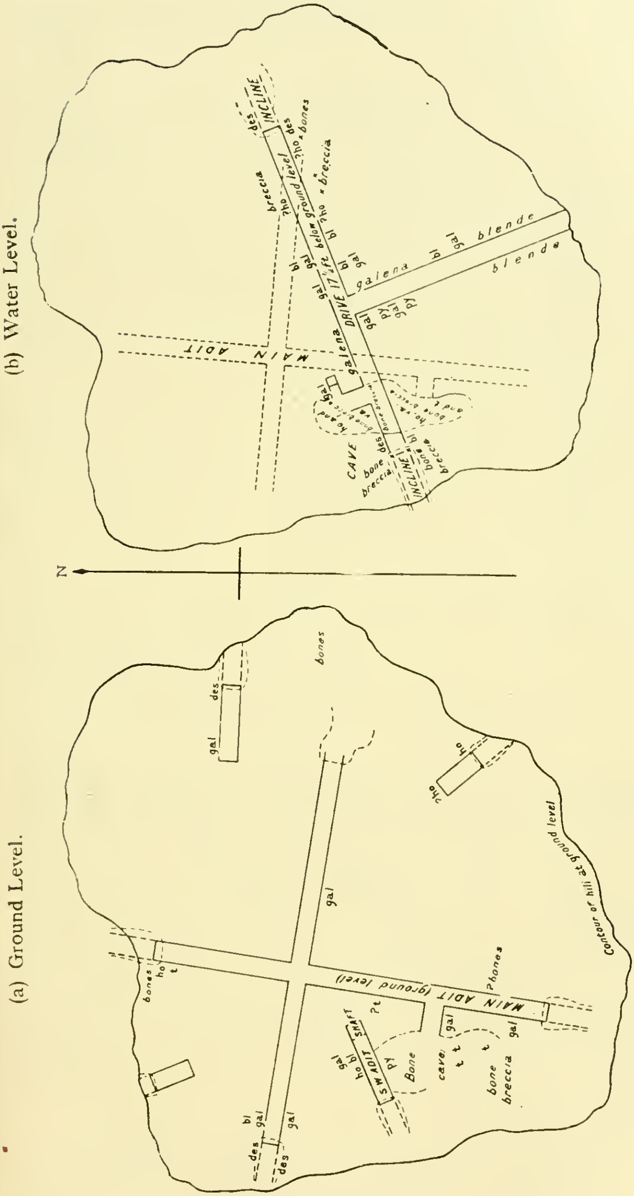


Fig. 3.

DIAGRAMMATIC PLANS OF "KOPJE NO. 1,"

Shewing distribution of Phosphates, Vanadates and Sulphides in Adits, Drives, etc.

gal = Galena	bl = Blende	des = Descloizite
py = Pyromorphite	t = Tarbuttite	va = Vanadinite
	ho = Hopeite	

been confined to the zone above the water-level. Occasional small patches of partly oxidized galena and blende are seen in the gossan of No. 1 Kopje, whilst galena is even to be found at the surface of the kopje. Galena associated with cerussite was noted in the bone cave in one of the walls from which the covering of hopeite and vanadinite had been broken away. The same mineral was found by Mr. White* in the cave earth in the form of small lumps. *Pyrite* and *Chalcopyrite* occur in very small quantities with the blende and galena in the crystalline limestone below water-level.

Cerussite is probably the commonest mineral in Kopje No. 1, but it was not found in Kopje No. 2. A little is present in Kopje No. 3. The mineral occurs in magnificent crystal aggregates encrusting the numerous cavities in Kopje No. 1. These cavities are sometimes several feet in diameter, and often contain nothing but cerussite. The mineral is present intimately mixed with hemimorphite, iron oxide, quartz, etc., in the pale brown and whitish rock which forms the larger part of the gossan right at the surface.† Sometimes the mineral is stalactitic, as was observed by Mr. Spencer.‡

Calamine (zinc carbonate) is present in very large mammillated masses in the phyllite and limestone of No. 2 Kopje, apparently being associated there with no other zinc or lead minerals. It also occurs rather commonly encrusting the cavernous surfaces of Kopjes 1 and 2, and occasionally associated with cerussite and hemimorphite in the crystal-lined cavities in Kopje No. 1.

Hydrozincite is beautifully developed in mammillated and rosetted crusts infilling cavities and seams in Kopje No. 2. It is not uncommon on the exposed surfaces of Kopjes 1 and 2 as an amorphous crust. The hemispherical soft, white and earthy masses believed by Mr. Spencer§ to be hydrozincite, were found in several instances to be well developed in Kopje No. 2.

Hemimorphite (zinc silicate) is largely present in Kopje No. 1, forming thick, partly crystallized and somewhat stalactitic crusts in cavities, some of which are large and completely lined with that mineral. Sometimes it is well crystallized. Often it is associated with cerussite or calamine and cerussite. Sky-blue hemimorphite occurs infilling smaller cavities. Perhaps the chief development of this mineral is that which forms an intimately intermixed aggregate with cerussite, quartz and iron oxide,|| and constituting the bulk of the gossan of Nos. 1 and 3. It also lines cavities in No. 3. A little doubtful hemimorphite occurs in cavities lined with other minerals in Kopje No. 1, and it is "present in crystallized crusts on the bones and on the bone-breccia in the cave."¶

Pyromorphite mostly occurs with tarbuttite in Kopje No. 2 in the extremely beautiful crystal-lined cavities. Like the tarbuttite, it is deposited on spongy limonite. Exceptionally beautiful bright-green crystals in loose aggregates are seen lining cavities in Kopje No. 2. These sometimes have no associated

* White *loc. cit.*, vol. vii. p. 17.
† Spencer, *loc. cit.*, p. 1.
‡ *Ibid.*, p. 36.
§ *Ibid.*, p. 35.
|| *Ibid.*, p. 34.
¶ *Ibid.*, p. 35.

tarbuttite, and almost continuously line cavities several feet in diameter, thickly covering parts of the cavity. A little pyromorphite was found at the surface of Kopje No. 1, and some occurs in a drive near the bone cave. ?Amorphous pyromorphite in curious very pale brown growths of small size was noted in small cavities in Kopje No. 2.

Hopeite was only noted in Kopje No. 1, where in the bone cave it forms beautiful crystallized coatings* more or less completely lining the cave as it existed when broken into. The thick mud and bone-breccia of the floor has plainly at some time subsided in part, so that at present the roof and floor of the lower cavity are composed of bone-breccia; this is thickly covered with vanadinite and hopeite resting directly on a very thin, minutely crystalline crust of ?tarbuttite and ?hemimorphite. The corroded form of hopeite occurs as a thick encrustation on one wall of the cave. In three other places in Kopje No. 1 a little hopeite has been found either with or close by mineralized bones (in one occurrence the mineral was only doubtfully determined, and in one other the mineral has been removed).

Parahopeite is so far the rarest of the zinc phosphates at Broken Hill. It occurs in small rosettes in the highest part of the bone cave, and perhaps to a very small extent in a drive in Kopje No. 2. In the Rhodesia Museum is a specimen of coarsely crystallised parahopeite in limonite. It is believed to have come from Kopje No. 2.

Tarbuttite is chiefly developed in Kopje No. 2, occurring in magnificent crystal coatings of considerable extent and various thicknesses in the numerous cavernous spaces of the dark-brown cellular limonite which occurs in the central part of the Kopje. In most instances it is associated with pyromorphite. A little tarbuttite was noted crystallized upon descloizite in Kopje No. 1 and in Kopje No. 3; a small development is also recorded from the cave, from whence it was detected by Mr. Spencer‡ as "very thin and minutely crystallized crusts on the hopeite specimens and on some of the bones." Tarbuttite was not noted in association with the fresh unaltered limestone.

?Goslarite.—A white, powdery mineral associated with blende, and encrusting that mineral and small patches of a wall of a lower drive in Kopje No. 1, is believed to be zinc sulphate, but unfortunately the sample was lost in transmission.

Descloizite is present in Kopje No. 3, occurring there in rather large aggregates of crystals, thin seams and crusts lining or infilling small fissures in the limestone and in small cavities 6 to 8 inches across, filled with coarsely crystallized descloizite on a surface of massive descloizite. It is associated with a little tarbuttite, etc. The mineral occurs as thin encrustations on portions of the surface of Kopje No. 1 associated with calamine, and close by an accumulation of mineralized bones.

On certain joint surfaces of the limestones containing cala-

* White, *loc. cit.*, vol. vii., p. 17.

‡ Spencer, *loc. cit.*, pp. 22, 30 and 38.

mine and in ferruginized ?limestones of Kopje No. 2 small groups and isolated crystals of descloizite were found to be rather common.

Vanadinite forms coraloidal growths and encrustations on the surfaces of the bone-breccia of the cave in Kopje No. 1. It is intimately associated with hopeite, and is generally overgrown by that mineral.

Limonite is exceedingly common in Kopje No. 2, being the substance of the cavities in which the beautiful pyromorphite and tarbuttite occur. It is very cavernous and pseudostalactitic. The mineral as yellow ochre is also common intermixed with hemimorphite, cerussite, etc., in the gossan of Kopjes 1 and 3. Massive limonite was noted in some of the drives of No. 2 Kopje. A little Göthite is also present.

Quartz, as implanted crystals lining small cavities in the gossan of Kopjes 3 and 4, occurs abundantly. To a lesser extent it is similarly present in Kopje No. 1.

Chalcedony is less common than quartz, but large masses are present in Kopjes 3 and 4.

Psilomelane, in the form of wad, is present in Kopje No. 2 in small amount.

Malachite was found in very small amount in Kopjes 1 and 2

?Azurite also was found, in very small amount, partly coating galena altering to cerussite.

Chrysocolla also was noted in Kopje No. 1, together with a little *? Dioptase*, which may, however, have been confused by the writer with *? Copper phosphate*, the pale-green mineral noted by Mr. Spencer as occurring in small bright-green (monoclinic?) crystals, and suggested by that author to be a copper phosphate. This mineral was noted in very small quantity in cavities in the surface ore of Kopje No. 1.

Dolomite is believed to be present in coarse aggregates in Kopjes Nos. 1 and 2, but it was not found *in situ* by the writer.

A white, pearly-lustred mineral in minute squat crystals present in Kopje No. 2 is believed to be a phosphate of zinc, but it is not yet identified. The form of the crystals does not seem to conform with any of those of previously described zinc phosphates.

No silicates of lead were detected, neither was greenockite found. These minerals were carefully searched for. Willemite is suspected, but could not be found by the author. Melaconite is suspected to be present in small quantity.

It is stated that traces of gold and silver have been detected by assay of material from Kopje No. 1.

V. Origin of the Phosphates and Vanadates.

By plotting out the results of the survey of certain of the minerals, important considerations concerning the relationship and origin of the beautiful phosphates and the vanadates are suggested (see Figs. 3 and 4). Firstly, the phosphate minerals of Kopje No. 1 are clearly restricted to the immediate vicinity of the bone deposits, with the exception of one or two insignificant occurrences which may be explained by the movement of the phosphoric acid in solution from its source of origin. The origin of the phosphate minerals occurring in Kopje No. 1 is therefore evident, namely, the reaction of phosphoric acid supplied by the leaching of the animal remains with the oxidized zinc and lead compounds. On Kopjes Nos. 2 and 3,

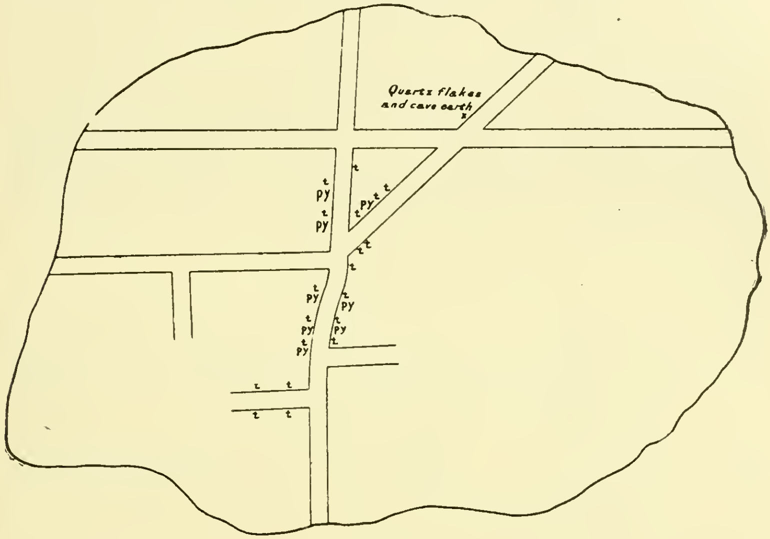


Fig. 4.

Diagrammatic Plan of "Kopje No. 2,"

Shewing roughly the distribution of Tarbuttite and Pyromorphite in Drives and Cross-cuts.

t = Tarbuttite

py = Pyromorphite

in both of which phosphate minerals are present, the evidences of the occupation of small ledges and crevices by man or beast or both are found. In Kopje No. 3, for instance, a large cavernous ledge between craggy walls is about 30 feet by 12 feet, narrowing at one end. Its floor, on which white quartz chips abound, consists of several feet of whitish, soft material full of pebbles. Further opening up of the deposit in Kopje No. 2 may almost certainly reveal the presence of a large bone deposit close to (probably above) the large phosphate zone which has been exposed in the drives.

Secondly, it is most interesting that the vanadium minerals are not found excepting close by, generally actually with, the phosphates. This is especially to be noted in the western group of Kopjes (Nos. 1 and 3). Conversely, most of the phosphate mineral occurrences known at Broken Hill have vanadium minerals either in actual contact or in close proximity. This seems to be important and suggestive when it is remembered that the element vanadium is one of a group—arsenic, phosphorus and vanadium—the members of which have a number of properties in common, and isomorphously replace one another in the mineral kingdom. Further work is necessary for the elucidation of this matter, which is beyond the scope of the present note.

A mixed sample of undecomposed blendiferous limestone of Broken Hill was carefully tested by Mr. J. B. Bull for the presence of vanadium; the concentrate of the limestone was also separately tested, but no vanadium was found, neither were vanadium minerals detected on examining microscopically the blende-bearing limestone; but it must be remembered that only a comparatively small amount of the sulphide limestone has been opened up. Further work may reveal the presence of vanadium in the unoxidized zone; meanwhile the author puts forward the suggestion that the origin of the vanadium is in some way closely connected with the presence of the phosphorus of the bones.

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1 L. J. Spencer. "On Hopeite and other zinc phosphates and associated minerals from the Broken Hill Mines, North-Western Rhodesia." *Mineralogical Magazine*, April, 1908, vol. xv, No. 68, p. 1.

2 Franklin White. "Notes on a cave containing fossilized bones," etc. "at Broken Hill, North-Western Rhodesia." *Proceedings of the Rhodesia Scientific Association*, vol. vii, part ii, 1908, p. 13.

3 Franklin White. "Further evidences of the occupation of the Caves at Broken Hill." *Proceedings of the Rhodesia Scientific Association*, vol. ix, 1909, p. 127.

4 E. C. Chubb. "List of Vertebrate Remains in Broken Hill Cave." *Proceedings of the Rhodesia Scientific Association*, vol. vii, part ii, 1908, p. 21.

5 F. P. Mennell and E. C. Chubb. "On an African Occurrence of Fossil Mammalia associated with Stone Implements." *Geological Magazine*, October, 1907, p. 443.

6 A. E. V. Zealley. "The Mineral Resources of Rhodesia." *Ninth Annual Report of the Rhodesia Museum*, 1910, pp. 40, 44, 45.

THE PURIFICATION OF WATER.

By Prof. Heinrich Bohle, M.I.E.E.

(Not printed.)

A BASUTO AND BENGALI FOLK TALE.

By Rev. Samuel S. Dornan, M.A., F.G.S.

(Not printed.)

ELECTORAL REFORM—PROPORTIONAL REPRESENTATION.

By John Brown, M.D., C.M., F.R.C.S., L.R.C.S.E.

(Evening discourse delivered in the Library Board Room, Bulawayo, on Tuesday, July 4, 1911.)

(Abstract.)

The lecturer began his address by alluding to a recent debate in the Rhodesian Legislative Council, the outcome whereof was the adoption of a motion requesting the Government to take into early consideration the subjects of additional representation and redistribution. Some of the speakers, he said, advocated single-member constituencies, and some referred to the transferable vote—the best means of securing effective voting and true representation. After outlining the method of employing the transferable vote, the lecturer said that while single-member constituencies result in strife and difficulties,, as the Union of South Africa was already experiencing, transferable voting tends to bring peace and progress and to promote united action in the problems which a legislature has to face.

The question of real representation is at present occupying a prominent place all over the world. Tasmania has secured effective voting, and all over Australia men were calling out for it. Every vote given should help to return a member, and thus become effective. There would thus be no more majorities and no more minorities, but every member would have his due share of all the votes, and the elected body would exactly represent the electors. However impossible this may seem, it is regularly carried out in the Pretoria and Johannesburg Municipal elections. The speaker then referred to the meeting of the National Convention at Durban, where, he said, its members began their work with the most important and fundamental matters, including the best method of Parliamentary election. They devised the most perfect system of electing both Houses of Parliament that the world had ever seen, one which made every vote effective, securing, as nearly as possible, one man, one vote; one vote, one value, and each member the same number of votes. A few months later, at Bloemfontein, this splendid system was given up, and they fell back on the antiquated, inaccurate British plan of single-member constituencies under which the non-effective sometimes outnumber the effective votes by six to one.

For true representation, the lecturer continued, the elected House should reflect, as in a mirror, the voters that elect it, but in practice sometimes only 15 per cent. of the votes help to elect the member, yet we delude ourselves with the idea that we have, by a majority of votes, elected a representative. True repre-

sentation can follow only when every possible vote is made effective. This can be done by sectional election; where each equal section of the voters elects not a member only, but a representative of all that section by the votes of all the voters in that section. By the British method of election this is absolutely impossible.

Single-member elections are seen at their best when there are only two candidates; and in such a case two points should be noticed: the number of voters that must of necessity be unrepresented, and the number of votes that are necessarily non-effective. Both these are inherent in single-member constituencies, and both are non-existent where there is transferable voting.

When there are more than two candidates the number of non-effective votes is enormously increased, for one more vote than the second-best candidate obtains secures the election of the member, and all the other votes are non-effective.

With our small number of voters in South Africa, the number of unrepresented voters, though proportionally large, looks small. In England it amounts to hundreds of thousands in every election: and this recurs year after year. In the General Election in 1906, in Wales 217,462 Ministerialist voters elected 30 members, while 100,547 Unionist voters elected *none,* and were unrepresented. On the other side again: in January, 1910, in Kent, Surrey, and Sussex, 218,000 Unionists got 30 members; 134,000 on the other side got none. Thus, in these two districts, 235,000 were unrepresented voters.

We have discussed two drawbacks inherent to single-member constituencies. A third, and very important one, is that a minority of voters may, and often does, obtain a majority of members: so that it is the minority which rules and not the majority, in these cases, under the present system.

In Warwickshire in 1906 there were four constituencies; three Liberal members were returned by 22,021 voters, and only one Conservative, though the Conservatives had 22,490, *i.e.*, a majority of 469 more votes. This resulted from the fact that the larger Conservative majority was all in one division, while the Liberal majorities were spread over the other three.

These drawbacks inherent in single-member constituencies are entirely absent in the true representation that the transferable vote secures in all cases.

By electing your members with the transferable vote, you would gain the five following advantages:—

The *first* is, that the mobile portion of your voters, who are working in one place to-day and elsewhere soon after, would suffer no disfranchisement; they could always vote wherever they happened to be working.

The *second* is a much more important matter. With a growing population, the question of additional representation comes up. With the transferable vote each member gets as far as possible the same number of votes or the quota. When, with an increased number of voters, there is an additional quota to spare over and above that at the last election, you have this increase very prominently made manifest, and you have an automatic index to the expediency of your claim to have one more member.

Thirdly, a very much more troublesome question—that of redistribution—would also be completely avoided. It is one of the most difficult and troublesome questions to settle; and with an increasing population it will become, not only a chronic, but a constant source of strife.

In the South African Union, after the Bloemfontein catastrophe, a Commission of highly-paid Judges—the very best men we could obtain—had to leave their judicial functions and busy themselves in settling the boundaries of 121 new constituencies, each with as nearly as possible 3,000 voters. This they accomplished with great difficulty just before the elections were held Within nine months the results of the new census showed us that, owing to the diminution of voters in Cape Town at one end, and owing to the influx of newcomers in the Rand at the other end, there will have to be a new redistribution with fresh boundaries, and the formation of fresh electoral divisions at both these places.

With single-member constituencies this will be your experience constantly, and time and energy will be frittered away on endless disputes, to the detriment of the country. All this needless trouble and loss would be avoided by the adoption of proportional representation and the transferable vote.

Fourthly, you would have one vote one value, and each member elected by the same number of voters, an utter impossibility with single-member divisions, or, in fact, with more divisions than one; for though each division might, as in the Union, contain as far as possible an equal number of voters, that would not ensure that in each an equal number of voters voted; and, unless they did, you can neither have one vote one value, nor the same number of voters electing the member.

Fifthly, by this system you would ensure the election of the very best men in the country. Canvassing would become impossible, so far as the whole constituency was concerned, and to a large extent unnecessary, so far as local interests go: for the contest would no longer be with other local candidates. Each division would have to concentrate on the strongest public man with local influence. Instead of a contest between local men, each spending money legitimately enough in asking for votes to get him in, you will have the voters themselves doing all this asking for votes, to procure the services of a good public man, who is willing to make the sacrifices that a devotion of a large portion of his time and attention to the service of the public will entail. Instead of a voter having only a choice, as often now, between two candidates, neither of whom he would himself prefer, every voter all over the country has the chance of selecting his candidates from the best men willing to serve. The field for the selection of candidates is widened. With the present necessary election expenses, some aspiring farmer, for example, who has taken a prominent part in doing public work among his fellows, promoting an agricultural society, or trying experiments to find breeds of animals suitable for the district he lives in; who, perhaps, through these very efforts, is not in a position to incur the necessary election expenses in a contested election, would have the way open to him to become a candidate; and with the good opinion of his fellow farmers might get in, and become a most valuable councillor. The same applies to the aspiring miner or the merchant.

Local influence would have full sway; for in most instances the bulk of the quota would be supplied in this way.

The lecturer proceeded to say that the fact that the transferable vote makes every vote effective would entirely alter the whole present situation as soon as the voter realised the power it gives him. He is the one who would profit most; but the benefits extend not only to the voter, but to the candidate, the member, and the country.

The voter would see the absolute necessity of recording his vote; of getting every other voter to do the same; of getting every man qualified to vote to have his name entered upon the register. Having the privilege of expressing his preference for as many candidates as he chooses, he would exercise it, and thus secure an effective vote.

As concerns the candidates, with the importance of canvassing much diminished, and that of merit as the member's qualification greatly increased, and with election expenses diminished or abolished, the field of choice would be extended. When past public services and the ability to render more are what is looked for in the candidate, you would have the best public men coming forward—not asking for votes, but offering their services for the public good, if a large enough section of the voters desired them. This honourable position would take the place of the present personal contest, conducted in large measure by the help of the candidate's purse.

As to the member, his position would be infinitely stronger. Collectively, the members would represent the whole community, and would thus be on a footing of perfect equality with their fellow-members on the opposite side of the House. Freed from the troublesome contentious subjects of additional representation and distribution, they could devote their energies entirely to the pressing needs of the country, to the advancement of its material interests, to profitable work, in the interests of those who elected them.

As to the country, its rate of progress would be increased, the needs and the wishes of its inhabitants would find such expression as they never had before, as an efficient instrument for securing this would be in their hands.

To recapitulate: The Union of South Africa, through ignorance of the great advantages the transferable vote confers, lost the inestimable boon of true representation. The system of single-member constituencies leaves large sections of the voters unrepresented, and a large majority of the votes unused; it utterly fails to secure representation, and under it a minority of the voters sometimes secures a majority of elected members; and in the British House of Commons in only one election in twenty-five years was there an approximation to representation. These drawbacks are impossible with the use of the transferable vote, which, through sectional representations, makes use of every vote it is possible to use in electing the members, and thus secures true representation. This system provides the question of additional representation with easy and satisfactory settlement; the troublesome question of redistribution is avoided; one vote one value can be secured; and the election is ensured of the very best public men whose local influence secures the support of those who know them best.

I have dwelt, the lecturer said in conclusion, on the enormous change this system produces in the position of the voter, the candidate, and the member, and of the good it would do in advancing the practical interests of the country. I remind you of your partnership with the Great Chartered Company of British South Africa, of the identity of your aims and interests, of the benevolent bureaucracy under which you live, and of the certainty of your getting this boon of true representation, if you can only spread the knowledge of its benefits far and wide.

As the best means of doing this I urge your forming at once a local branch of the Proportional Representation Society. With you lies the great responsibility of preventing a repetition in Rhodesia of the catastrophe the Union of South Africa suffered at Bloemfontein.

THE GYROSCOPE.

By W. H. Logeman, M.A.

(*Evening discourse delivered in the Library Hall, Bulawayo, on Thursday, 6th July,* 1911: *illustrated by models and experiments.*)

The lecturer explained the working of Brennan's mono-rail railway, and the application of the gyroscope to the steadying of ships.

A RELATION BETWEEN THE GEOLOGY AND METALLURGY OF GOLD.

By F. T. Mumford, A.I.M.M.

(*Abstract.*)

The author classifies the best-known gold mines in Rhodesia under three main heads, namely: (1) Deposits in which gold may have been laid down with the strata owing to decomposition of a gold-bearing rock; (2) reefs and masses of igneous origin where the gold has crystallised out with the matrix; and (3) sedimentary schistose deposits. The first of these three groups he subdivides into (*a*) recent alluvial deposits, and (*b*) conglomerates. Group 2 is subdivided into (*a*) true fissure, imbedded and gash veins, and (*b*) masses of igneous origin. He then points out incidentally that different treatment is required for schistose and for igneous deposits. He goes on to say that alluvial deposits (group 1*a*) are generally treated by catching the coarse grains of gold in ripples and amalgamating the fines, and that conglomerates (group 1*b*) may also be amenable to direct amalgamation and cyanidization after reduction to a sufficiently fine state to allow of the fullest application of those processes. The Witwatersrand, Shamva and Eldorado occurrences are mentioned in illustration. Reefs and masses of igneous origin, provided no base metal, such as copper, antimony, or arsenic is associated therewith, would also be free milling. Of the schistose deposits the author mentions the "Enterprise" and "Cam and Motor" as examples. He explains the refractory nature of these deposits by assuming the metal to be either in a state of chemical combination or present as brown amorphous gold, and therefore gold in this condition needs for its extraction specially designed plants. The "French Bobs" and "Mount Morgan" occurrences are quoted as instances hereof, and under the most favourable conditions, it is stated, samples from these mines will not show more than a 50 per cent. extraction with ordinary treatment. The geological formation with which the gold is associated has, therefore, in the author's opinion, a distinct bearing on the metallurgy of the ore.

ELECTRIC CLOCKS.

By Prof. Heinrich Bohle, M.I.E.E.

(*Not printed.*)

ADDITIONAL NOTES ON EVOLUTION.

By David Traill, M.A., M.B., Ch.M., B.Sc.

(*Abstract.*)

Assuming his previously advanced views* to be true, namely, that at the birth of organic life the earth's atmosphere contained much carbon dioxide and little or no oxygen, and that the quantity of the former has been gradually diminishing and that of the latter increasing, the author considers the conclusion inevitable that there must have been a correspondingly slow and steady change in all organisms living in this changing atmosphere. Accordingly he restates the proposition enunciated in the above-mentioned paper with regard to the existence of a regulating centre in every organism.† He lays down, further, that when the interests of the individual conflict with those of the race the greatest good of the greater number determines the issue. In plants, the author remarks, this is exemplified in an individual, for whose growth conditions are favourable, when all its individual needs are met and flower production is not hurried on, but where some check or reminder that its individual life is in danger is at once responded to by a stoppage of the growth of leaves and branches and a devotion of all energy to hastening on seed production and the fulfilment of its destiny ere it is too late. In animals the author sees an exemplification of his views in the changes that occur in a mother during development of a fœtus, the latter, as representing the race, being jealously cared for by the regulating centre even at the expense of the mother who represents merely the individual.

The author then offers some remarks on the subject of heredity. He considers it agreed that innate or endogenous qualities are transmissible, and as to acquired or exogenous characters, he holds that if these are not inherited there cannot be evolution. To Prof. Thomson's remark, that we do not know of any clear case which would at present warrant the assertion that an acquired modification is ever transmitted from parent to offspring, he replies that the reason of this ignorance lies in the brevity of human experience and its consequent incapacity to measure nature's slow progress during thousands of millions of years.

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* Report S. A. Ass. for Adv. of Science; Cape Town, 1910, pp. 290-305.
† *Loc. cit.*, p. 300.

THEORIES OF ATMOSPHERIC VARIATION.

By David Traill, M.A., M.B., Ch.M., B.Sc.

(*Abstract.*)

The author refers to the views enunciated by him at Beaufort West on the 13th June, 1910, and in his previously published paper,* subsequent to which he had found similar theories put forward by Prof. Arrhenius. The idea that there had been successive waves of plant and animal life on the earth, due to corresponding waves in the proportions of carbon dioxide and oxygen in the air, he considers to be untenable. He criticises adversely Sir E. Ray Lankester's statement that, in the absence of green plants, animals would eat one another, use up the oxygen of the atmosphere, and be suffocated for lack of that gas. He holds that all the carbon in animal bodies, if the latter formed a closely compacted layer round the earth, six feet in height, would be insufficient to use up the present atmospheric oxygen: there would, the author considers, still remain about 2,000 parts of oxygen and 4 parts of carbon dioxide in every 10,000 parts of air. The output of carbon dioxide, he states, is limited by the quantity of carbon available, and there is not at present enough unoxidised carbon on the earth's surface to increase the amount of carbon dioxide in the atmosphere from four to five parts per 10,000.

TRANSACTIONS OF SOCIETIES.

Geological Society of South Africa.—Monday, April 15th: Mr. H. S. Harger, President, in the chair.—" Note on an interesting dyke intrusion in the Upper Waterberg System:" Dr P. A. **Wagner.** The dyke referred to is exposed in some excavations on the farm Buffelspruit, north-west of Warmbaths, the country rock being massive Waterberg sandstone. According to its mineralogical composition the rock is a camptonite, but on the basis of its chemical constitution it may be grouped with the monchiquites. Such dykes are invariably associated with the elæolite syenites and allied plutonic rocks, but in the area where this dyke occurs no elæolite syenite is known to exist. This led the author to remark on the relative ages of the plutonic members of the Bushveld Complex, and he concluded that there was no justification for assigning a post-Waterberg age to all occurrences of elæolite syenite in the Bushveld Complex.—" The Nama System in the Cape Province:" Dr A. W. **Rogers.** The author showed that the three series of rocks known as the Nieuwerust, Malmesbury and Ibiquas beds are parts of one great group, which is the same as that known as the Nama System in German South-West Africa. The true sequence of the three series is that given above, the Nieuwerust beds being the oldest. The great gneiss and granite area, which extends north from the Moed Verloren Hills to beyond the Orange River, include acid intrusive rocks of two different dates, the earlier of pre-Nama age, and the latter post Malmesbury, and probably post-Ibiquas.

* Report S. A. Ass. for Adv. of Science; Cape Town, 1910, pp. 290-305.

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1911.

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Members are requested to be so kind as to remit the amount as soon as possible to the Assistant General Secretary, P.O. Box 1497, Cape Town. Unless such members pay the amount due at an early date, great inconvenience and probably unnecessary expense will be caused, as it is very difficult to determine what number of copies of the Journal will be required. The Council therefore appeals to every member for support and co-operation, and asks that outstanding subscriptions be paid without delay. The Journal will be sent only to those whose arrear subscriptions are paid.

Cheques, etc., should be crossed and made payable to the Association; 6d. should be added to country cheques for exchange.

Cape Town, 15th July, 1912.

PROCEEDINGS OF THE ASSOCIATION.

Copies of the following volumes (Royal 8vo.) of the Association's Reports may be obtained from the Assistant General Secretary (P.O. Box 1497, Cape Town) at the prices set against them:

Vol. I.—Cape Town, 1903. 556 pp. Price, 10s. net; to Members, 5s.
Vol. II.—Johannesburg, 1904. 598 pp. Price, 10s. net; to Members, 5s.
Vol. III.—Kimberley, 1906. 676 pp. Price, 20s. net; to Members, 10s.
Vol. IV.—Natal, 1907. 230 pp. Price, 10s. net; to Members, 5s.
Vol. V.—Grahamstown, 1908. 436 pp. (Out of print).
Vol. VI.—Bloemfontein, 1909. 538 pp. Price 30s. net; to Members, 15s
Vol. VII.—Cape Town, 1910. 480 pp. Price 20s. net; to Members, 10s.

One shilling should be added to the cost of each of the above volumes for postage.

The Association has also on hand a few copies of the Report of the Meeting of the British Association in South Africa in 1905; price 24s.; to members, 10s. 6d.

"Science in South Africa."—A few copies of this valuable handbook, which was specially prepared for the Members of the British Association visiting South Africa in 1905, are for sale, price 7s. 6d. (or 8s. 6d., post free).

INFORMATION REGARDING THE ASSOCIATION.

Objects.—The objects of the Association are:—To give a stronger impulse and a more systematic direction to scientific enquiry; to promote the intercourse of Societies and individuals interested in Science in different parts of South Africa; to obtain a more general attention to the objects of pure and applied Science, and the removal of any disadvantages of a public kind which may impede its progress.

Life Members.—Life Members shall be eligible for all offices of the Association, and shall receive gratuitously all ordinary publications issued by the Association. Every Life Member shall pay, on admission as such, the sum of Ten Pounds. An Ordinary Member may at any time become a Life Member by one payment of Ten Pounds in lieu of future Annual Subscriptions.

Ordinary Members.—Ordinary Members shall be eligible for all offices of the Association, and shall receive *gratuitously* all ordinary publications issued by the Association during the year of their admission, and during the years in which they continue to pay *without intermission* their Annual Subscription. The Entrance Fee for ordinary members is One Pound, and the Subscription is One Pound, payable first at election and thereafter on the 1st of July of each year.

Associates.—Associates are eligible to serve on the Reception Committee, but are not eligible to hold any other office, and they are not entitled to receive gratuitously the publications of the Association. The Subscription for Associates for a Session is Fifteen Shillings.

Ladies.—Ladies may become Members or Associates of the Association.

Townshend, Taylor and Snashall, Printers, Cape Town.