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MARCH, 1884.

VOL. II. FASCICULUS No 1.

PROCEEDINGS

OF

THE CANADIAN INSTITUTE,

TORONTO,

BEING A CONTINUATION OF THE "CANADIAN JOURNAL" OF SCIENCE, LITERATURE AND HISTORY.

CONTENTS:

TORONTO:
COPP, CLARK & CO.
1884.

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TORONTO:
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1884.

PROCEEDINGS

OF

THE CANADIAN INSTITUTE,

SESSION 1883—1884.

FIRST ORDINARY MEETING.

The First Ordinary Meeting of the Session 1883-84 was held on Saturday, November 3rd, in the Library of the Institute, the President, J. M. Buchan, M. A., in the chair.

The minutes of last meeting were read and confirmed.

The following list of exchanges, donations and purchases received from April 1st to November 3rd, 1883, was presented:

I.—DONATIONS.

1. Report of the Superintendent of the U S. Coast and Geodetic Survey, showing the progress of the work during the fiscal year ending June, 1880.
2. The Bystander, N. S., No. 1, January, 1883, by James Bain, jun., Esq.
3. Report of the Commissioner of Agriculture for the United States, for the years 1881 and 1882.
4. Statutes of Ontario for 1883.
5. The Canadian Parliamentary Companion for 1883, by J. A. Gemmill, Esq.
6. A glacial striated stone from boulder clay, shore of Lake Erie, Kingsville, Essex Co., presented by David Boyle, Esq.
7. Annual Reports of the Commissioner of Agriculture and Public Works for the Province of Ontario, on Agriculture, and the Arts, for 1872, 1873, 1874, 1876, 1877, 1878, 1879, 1880, 1881, 1882, (10 vols.) per Professor Buckland.
8. Report of the Superintendent of Insurance for the Dominion of Canada for the year 1882; from the Superintendent of Insurance, Dominion of Canada.
9. Catalogue of the Library of the Peabody Institute of the city of Balti more, Vol. I., containing letters A to C; from the Board of Trustees of the Peabody Institute.
10. Check List of Insects of the Dominion of Canada, compiled by the Natural History Society of Toronto; from the compilers.

11. Journal of the Anthropological Institute of Great Britain and Ireland, 11 Nos. of various volumes to complete a set; from the Anthropological Institute.
12. Report of Canadian Archives, by Douglas Brymner, Esq., Archivist, 1882; from the Department of Agriculture, Ottawa.
13. Mémoires de la Société Académique Indo-Chinoise de Paris. Four publications from the above Society.
14. The Literary Bulletin (11 Nos.) and Bibliographical Contributions (7 Nos.) of the Harvard University Library; from the Librarian.
15. Four reports of the Peabody Institute, city of Baltimore.
16. Historical collections of the Essex Institute, 12 volumes and parts, completing a set; 13 pamphlets from the same institution.
17. Proceedings of the Academy of Natural Sciences, Philadelphia, 10 parts and volumes to complete a set.
18. The Worcester Society of Antiquity, 5 Nos., completing a set.
19. The Journal of the Linnean Society, No. 70, Vol. XIII., completing a set.
20. The Journal of the Royal Dublin Society, 8 volumes and numbers to complete a set.
21. Annals of the Lyceum of Natural History, New York, 9 volumes and numbers; Transactions of the N. Y. Academy of Sciences, 7 numbers, completing sets; from the N. Y. Academy of Sciences.
22. From the Royal Geographical Society: The Journal of the Society, Vols. 47 and 48; the "Proceedings," 8 numbers, completing sets.
23. The Museum of Comparative Zoology at Harvard College, 4 numbers.
24. Proceedings of the Royal Colonial Institute, 5 volumes.
25. Leeds Philosophical and Literary Society, six Annual Reports, and seven pamphlets on various subjects.
26. Transactions of the Royal Scottish Society of Arts, 19 parts, to complete a set.
27. La Société des Ingénieurs Civils, Paris: 12 Nos. Mémoires et Compte Rendu des Travaux de la Société for 1882.
28. The Smithsonian Institute, Washington: 6 Vols. Smithsonian Contributions to Knowledge, Vols. 18—23, completing a set; 17 Vols. Smithsonian Miscellaneous Collections, Vols. 11 to 27 inclusive; 15 Vols. of Annual Reports of the Board of Regents of the Smithsonian Institution for various years.
29. Victoria Institute: Vols. 6 to 16 of the Journal of the Transactions, to complete set; sent to Messrs. Campbell & Son for transmission.
30. Institution of Civil Engineers: Vol. 57, to complete set.
31. The Canadian Entomologist, 3 Nos. to complete a set.

II.—EXCHANGES.

CANADA:

The Canadian Entomologist, Nos. 4 to 8, 1883.

Canadian Naturalist, Vol. 10, No. 8.

Bulletin of the Natural History Society of Quebec, No. 2.

The Canadian Practitioner, Nos. 5—11.

Transactions of the Literary and Historical Society of Quebec, session of 1882-83.

The Weekly Health Bulletin, issued by the Board of Health of Ontario.

The Monthly Weather Review of the Meteorological Service, Dominion of Canada, April to September, 1883.

Report of the Meteorological Service, Dominion of Canada, for the year ending December 31, 1882.

Manitoba Historical and Scientific Society, Winnipeg, Catalogue of 340 Specimens from their Collection.

Report and Collections of the Nova Scotia Historical Society for the years 1882-83.

UNITED STATES OF AMERICA:

The Journal of the Franklin Institute, Philadelphia, April to November, 8 Nos.

The American Journal of Science, April to November, 8 Nos.

Transactions of the Connecticut Academy of Arts and Sciences, 5 Vols., from the commencement in 1857, to 1882.

Proceedings of the Boston Society of Natural History, Vol. 21, Part 4, Vol. 22, Part 1.

Memoirs of the Boston Society of Natural History, Vol. 3, Nos. 6 and 7.

Science, from the commencement to No. 38.

Proceedings of the American Antiquarian Society, Vol. 2, Parts 2 and 3.

Bulletin of the Philosophical Society of Washington, Vols. 4 and 5, 1880-82.

The Pennsylvania Magazine of History and Biography, Vol. 7, Nos. 1, 2 Vol. 6, No. 4; and Vol. 3, No. 2.

Bulletin of the American Museum of Natural History, Vol. 1, Nos. 2, 3, 4, and 14th Annual Report.

Scientific Proceedings of the Ohio Mechanics' Institute, Vol. 1, No. 4, and Vol. 2, No. 2.

Worcester Society of Antiquity, No. 15, and No. 12, Part 4; No. 3, 1877; No. 12, 1880; No. 19, 1882.

Bulletin of the Museum of Comparative Zoology, Cambridge, Mass. Vol. 10, Nos. 5 and 6.

Journal of Speculative Philosophy, Vol. 17, Nos. 1 and 2.

Account of the Semi-Centennial Celebration of the City of Buffalo.

Report of the Director of the Observatory of Yale College for 1882-83.

Harvard University Bulletin, No. 26.

MEXICO:

Tomo 3, Entrega 2ª and 4ª.

ENGLAND:

Transactions of the Manchester Geological Society, Vol. 17, Parts 5, 6 and 7.

Proceedings of the Royal Geographical Society, April to October, 1883.

Journal of the Royal Microscopical Society, April to October.

Institution of Civil Engineers, Vols. 71, 72, 73.

Transactions of the Royal Scottish Society of Arts, Vol. 10, Part 5.

Journal of the Transactions of the Victoria Institute, April to October.

Journal of the Anthropological Institute, April to October, 1882.

Transactions and Proceedings of the Botanical Society of Edinburgh, session 1882-83.

Scientific Roll for 1883.

Proceedings of the Royal Colonial Institute, 1882-83.

Report and Proceedings of the Belfast Naturalists' Field Club.

Annual Report of the Leeds Philosophical and Literary Society for 1882-83,

Transactions of the Edinburgh Geological Society, 1882.

Journal of the Linnean Society.

Proceedings of the Royal Irish Academy, Nos. 9 and 10, Dec., 1882, June, 1883.

Transactions of the Royal Irish Academy, Nos. 11, 12, 13.

INDIA :

Records of the Geological Society of India, Vols. 15 and 22.

Memoirs of the Geological Survey of India, Vol. 19.

Palæontologia Indica, Series 10, Vol. 2 ; Series 14, Vols. 1 and 3.

NEW SOUTH WALES :

Report of the Department of Mines.

Minerals of New South Wales.

New South Wales in 1881.

Journal of the Royal Society of New South Wales.

NEW ZEALAND :

Transactions and Proceedings of the New Zealand Institute for 1882.

FRANCE :

Mémoires de la Société Nationale, des Sciences Naturelles de Cherbourg, Vol. 23, 1881.

Bulletin de la Société Geologique de France, 1879—1883, 16 Nos.

Mémoires et Compte Rendu de la Société des Ingénieurs Civils, April to October, 1883.

SWEDEN :

Acta Universitatis Lundensis, Vols. 15, &c., 7 Vols.

GERMANY AND AUSTRIA :

Göttingen—Nachrichten von der K. Gesellschaft der Wissenschaften, Nos. 1—23, 1882.

Munchen—Sitzungsberichte der Mathematisch-Physikalischen Classe der K. B. Akademie der Wisssenschaften zu München, Hefte 2, 3, 4, 5, Band 12, 1882.

Sitzungsberichte der Philosophischen, Philologischen und Historischen, Classe K. B. Akademie der Wissenschaften zu München, 1882, Hefte 1, 2, 3, Band 1 ; Hefte 1, 2, 3, Band 2 ; 1881, 4 and 5.

Astronomische, Magnetische und Meteorologische, Beobachtungen an der K. K. Sternwarte, for 1882-3.

Wien—Jahrbuch der K. K. Geologischen Reichsanstalt for 1882.

Verhandlungen der K. K. Geologischen Reichsanstalt, Nos. 12-18.

HOLLAND :

Haarlem, Archives Du Musée Teyler, Série 2, 3 Part, 1882.

Archives Neerlandaises des Sciences Exactes et Naturelles, 1882, June 17, 3, 4 and 5 Pts. : 1883, June 18, 1 Pt.

COPENHAGEN :

Oversigt over det K. Danske Videnskabernes Selskabs 1882.

Bulletin for 1882, No. 2.

III.—PURCHASES.

Life of Sir William Logan, by Harrington.

The Canadian Naturalist and Geologist. Vols. 1, 5 and 7 to complete sets.

The Journal of Speculative Philosophy, Nos. 1, 2 and 3, Vol. 10; No. 3, Vol. 11; Nos. 1, 2 and 3, Vol. 12; No. 1, Vol. 13; No. 3, Vol. 14.

The Bystander, Nos. 2, 3 and 4.

The American Journal of Science; 31 numbers to complete set.

And the various Periodicals mentioned in the last Annual Report, from April to November, 1883.

The President then delivered his Inaugural Address on

COMPLEXION, CLIMATE AND RACE.

MEMBERS OF THE CANADIAN INSTITUTE, LADIES AND GENTLEMEN:

I appear before you this evening to read the introductory paper of the session, but before doing so I wish to express my sense of the honour which my fellow members have conferred upon me by electing me a second time to the high office of President of the Canadian Institute. I wish likewise to acknowledge the heartiness of the aid and support which they gave to the Institute during last session, and to express the hope that the same unselfish and disinterested feelings which have hitherto prompted them to encourage what is done here for the advancement of science and the diffusion of knowledge may continue to operate in their breasts. The increase in membership, and the general success of the Institute during last winter, give rise in my mind, to good auguries for its prosperity during the session which commences to-night. Though the Council was unable during last session to accomplish everything that could have been wished, I think all will agree that it effected a great deal; and I confidently anticipate that much of the work which is not yet finished will be overtaken before next May. The labour of putting our library and collections in order has proved much more serious than was anticipated, but a very large part of the work has been done, and our active and efficient Assistant-Secretary, Mr. Young, has already put them so far into shape, that he is now in a position to say what we do, and do not possess, in most departments. I may add that the number of periodicals which we take, and that of societies with which we exchange publications have been considerably increased, and that, in

consequence, our facilities for affording the student of any special branch of knowledge an acquaintance with what the rest of the world is doing in it, are much improved. It may also be stated, that arrangements have been made whereby it is expected that a fuller and more regular printed report of our proceedings will be given to our members.

It seems to me that it would be inappropriate not to say a word on this occasion about the results that have flowed from a proposal made by Mr Sandford Fleming in a communication read before the Institute two or three years ago. I refer to the proposal to adopt certain meridians as standards of time—a proposal which is to take practical effect during the present month over a great part of this continent. The members of the Institute, seeing that they have in their corporate capacity twice memoralized the government, and taken other action in this matter, and in their separate capacities have seconded Mr. Fleming whenever they have had opportunity to do so, cannot but feel pleased that so much has been accomplished; and while I give utterance to that feeling of pleasure, I am sure that I am also speaking the mind of the Institute, when I express the hope, that this partial adoption of Mr. Fleming's scheme on this continent, may be but the prelude to its adoption in its entirety throughout the world.

Some years ago I had the honour to communicate to the Institute the general views at which I had then arrived in regard to the very difficult subject of the relations of complexion and climate. Though I cannot pretend that the partial solution which I then offered, was, even as far as it went, entirely satisfactory, I still think that it embodied an element of truth. Since that time, I have gained, if not increased light, at least additional information, and it has occurred to me that a new paper on the subject, written, not so much with the object of advancing any special views which I may hold, as with that of pointing out the nature of the difficulties which crop up when one attempts to elucidate it, and the character of the questions, with the solution of which its elucidation is connected, might prove to be of some popular interest.

This topic belongs to the domain of Anthropology, a science which has lately come into existence. The anthropologist might take for his motto that oft-quoted line of Pope's

"The proper study of mankind is man,"

but he would give it a meaning and an application which would astonish its author. Anthropology literally means, the science of man, and, if the term were construed in the full extent of its meaning, it would embrace all other sciences. It is not, however, so used, but is employed to designate the science which deals with the natural history of man. That is to say, Anthropology is a branch of Zoology. The great poet of the age of Queen Anne thought, and expressed the thought that the proper study of mankind is man, with the implication that it is his moral nature which is especially worthy of investigation; the anthropologist of to-day, without leaving man's moral nature out of account, feels more at home in questions about the shape and size of skulls, the height, weight, and colour of different races, the character of their hair, the peculiarities of the different parts of their skeletons, the relations of languages, and the development of civilization on the earth.

There is no one of the differences which separate one tribe or nation from another more striking than that of colour. In consequence, men are often classified in popular parlance into white and coloured. Blumenbach, about a century ago, divided mankind on the basis of colour into five races: the Caucasian or white, the Mongolian or yellow, the American or red, the Malay or brown, and the Ethiopian or black; and this classification has, in virtue of its simplicity, until recently been very generally accepted. It is, however, scientifically worthless. The so-called Red race varies in colour from chocolate brown to dark white. There are Chinese, Japanese and Coreans, which races, according to Blumenbach, are Mongolian, as white as many so-called Caucasians; and the Zulus of Southern Africa, though ranked as Ethiopians, present examples of every variety of complexion from yellow to black.

In place of Blumenbach's system a great number of classifications have been offered. These may be divided into those based on language, and those based on physical peculiarities. Both are alike unsatisfactory; the former because they often bring together tribes and nations of very different appearance; the latter because they separate races having related languages, and connect races whose languages are extremely different. In the Indo-European family, which is a division with a linguistic basis, are included the bronze-coloured Hindoo and the blonde Scandinavian. Among the Xanthochroi, or blonde whites of Huxley, a race set apart on the basis of its

physical characteristics, are included the Mingrelians of Circassia, the Scandinavians, and the Finns, three races speaking radically unlike languages, while the Samoyedes, whose language is related to that of the Finns, and the Persians and Hindoos whose tongues resemble that of the Scandinavians, are relegated to other classes.

From facts which have occurred, and facts which we may see daily occurring in this country and the neighboring republic, we are led to the conclusion that the language a man speaks is not good evidence as to his descent. The descendants of the Dutch settlers of New York speak English. The Negroes of the South speak either English or French. On the other hand physical peculiarities change very slowly, if at all. The Spaniard of South America, the Englishman of Virginia, the Frenchman of Quebec seem to be precisely the same physically as the Spaniard of Spain, the Englishman of England, and the Frenchman of France. If the white race darkens within the tropics, or the Negro blanches under the influence of frost, the process is very slow. It would therefore seem the part of wisdom to accept a classification based on physical peculiarities. The most approved classification is that of Huxley, which is founded on the character of the hair and colour of the skin. He divides all mankind into Ulotrichi, that is, those possessing crisp or woolly hair, and Leiotrichi, or those possessing smooth hair. The colour of the former, that is, of the Ulotrichi, or the woolly-haired division of mankind, "varies from yellow-brown to the darkest hue known among men." Their "hair and eyes are normally dark, and with only a few exceptions (among the Andaman Islanders) they are dolichocephalic," that is, long-headed. "The Negroes and Bushmen of ultra-Saharal Africa, and the Negritos of the Malay Peninsula and Archipelago and of the Papuan Islands are the members of this Negroid stock."

The Leiotrichi, that is, the smooth-haired division of mankind, are divisible into four groups, typified respectively by the Australians, the Chinese, the Swedes, and the Spaniards.

1. The first of these, namely the Australioid group, have dark skins, dark eyes, "wavy black hair, and eminently long skulls with well developed brow ridges, and projecting jaws." This group includes the native Australians and Tasmanians, and some races found in India in the Dekhan. Professor Huxley is inclined to consider the ancient Egyptians a modification of this type.

2. The second, or Mongoloid group, have for the most part "yellowish-brown or reddish-brown skins, and dark eyes, the hair being long, black and straight." Their skulls range between the extremes of long-headedness and broad-headedness. The group includes "the Mongol, Tibetan, Chinese, Polynesian, Esquimaux and American races."

3. The third, or Xanthochroic group, have "pale skins, blue eyes, and abundant fair hair. Their skulls, like those of the Mongoloid group, range between the extremes" of long and broad-headedness. "The Slavonians, Teutons, Scandinavians and the fair Celtic-speaking people are the chief representatives" of this type, but it extends "into North Africa and Western Asia."

4. The dark whites, or Melanochroi, constitute the fourth group. They are "pale-complexioned people with dark hair and eyes, and generally long, but sometimes broad skulls." The group includes "the Iberians or Basques and 'Dark Celts' of Western Europe, and the dark-complexioned white people of the shores of the Mediterranean and of Western Asia and Persia." Professor Huxley is inclined to hold that the Melanochroi are not a distinct group, but result from a mixture of Australioids and Xanthochroi, or fair whites.

It will be noticed that this classification brings together the widely separated Negroes and Negritos, neither of which races is maritime. The Australians are likewise ranked with the Todas and some other tribes of the Dekhan, though neither branch has reached a stage of civilization that would enable it to build ships and cross seas. From what Professor Huxley says in regard to the origin of the Melanochroi, or dark whites, it seems fair to infer that he would explain these difficulties by the hypothesis of a once continuous belt of Negro population from New Guinea to Africa, and a once continuous belt of Australioid populations from Australia to Britain. As these two belts cover to a great extent the same ground, we have another difficulty which we must solve by assuming the intrusion of either the one race or the other, and either Australioid or Negro conquest.

These difficulties suggest, that possibly after all, Huxley's classification does not indicate relationship or common descent. The Negroes and Negritos may resemble each other, not because they are of the same stock, but on account of the fact that the sum total of their surroundings, or in other words, of their environment, is similar, and

produces similar effects upon those subjected to it. That is to say, the Negrito of Malacca and the Philippine Islands may resemble the Yoloff and the Bantu of Africa, because his climate and mode of life are similar. If this is not the case, it is singular, that, over the vast area in which either the Negrito or the Australian must have supplanted the other, there should be no evidence of mixture of race, no remains of a mixed race evidently sprung from the union of the two. You may say to me, that one race exterminated the other. I say that in early times it was impossible to conquer and exterminate a race over a vast area. It is hardly possible now for a very civilized to extirpate a very uncivilized race over a large tract of country. Much less was it possible then, when all the devilish enginery of modern war had not been invented, and the process of killing one's fellow was slow, and very far from sure.

We shall be still more doubtful of the value of the preceding classification as a guide to community of descent, when we notice how the shape of the skull, which one would think would be as fixed as the colour of the skin or the character of the hair, varies in all but the Australioid division. We know that abundance of good food will increase the size of many of the lower animals, and that by a process of artificial selection from among the varieties naturally produced we can change almost any character to an indefinite extent. May it not possibly be the case that the shape of the skull, and the colour of the skin, hair, and eyes and other physical characters may be the results of that natural selection which Darwin puts forward as the operative cause in originating species.

A great deal of light would be thrown on the question we have just raised, if it could be clearly shown that some physical character was either independent of, or dependent on the environment. For various reasons the character of colour seems to give greater promise of results than any other. We have a greater abundance of information in regard to it than any other, and it seems at any rate at first sight to vary according to a law.

"The colour of the skin" in the different races "varies from the very pale reddish brown of the so-called white races, through all shades of yellow and red brown to olive and chocolate, which may be so dark as to look black." That of the hair, varies from the flaxen of some northern races, to a very deep brown or bluish black. That of the eyes varies from a very light blue through different shades of blue,

or grey, or green, to a more or less dark brown. Fair hair, and blue, green, or grey eyes, are never found except in conjunction with a white skin. The yellow hair reported as seen in some countries in conjunction with a dark skin, is the result of the use of a bleaching agent. Light eyes may occur with dark hair and a fair skin, and dark eyes with a fair skin and fair hair. The great majority of mankind have dark eyes, dark hair, and a more or less dark skin, and Huxley's Xanthochroi, or the blonde whites of Northern Europe, are the race that departs farthest from the common type.

According to Professor Huxley, there must once have been somewhere an unmixed blonde white race, by mixing with which the Australioids of the Mediterranean region and Great Britain became blanched to their present hue. There is not, however, what one would think there ought to be on that theory, any country or part of a country inhabited only by blondes. Probably the country with the greatest proportion of fair whites in it, is Southern Sweden; but here there is no inconsiderable admixture of men of the dark white race. On the contrary, there are countries inhabited solely by Melanochroi or dark whites. Such for example are Persia and Northern Arabia. These facts, namely, that there is no tribe or nation of unmixed blondes, while there are some of unmixed brunette whites, would seem to indicate, that the fairness of the people in the native country of the white race, is due to climatic causes, which produce their maximum effect in those parts where there are most blondes.

At first sight nothing appears plainer than that complexion is a result of climate.

The very dark races are near the equator, the light-colored ones in the temperate zones. The explanation seems to be at least as old as Homer that darkness of skin results from the intensity of the sun's rays. In his poems the term Æthiopes, meaning burnt faces, the root of our word Ethiopian, is used to designate an African tribe. But a very slight extension of our knowledge shows that this theory does not explain the facts. Side by side in the same country, as, for example, India, we find races of differing color who, apparently, have occupied the same soil for many centuries. On the forty-fourth parallel of latitude, which runs a little north of this city, we find, in the old world, the European brunette, the blonde Circassian, and the yellow Mongol, while on this continent we have the brown reddish

or yellowish Indian. On the equator itself we have the African Negro, the brown Malay of Borneo, and the yellow Tupi of the valley of the Amazons. North of the blonde Russian is found the yellow Samoyede, south of the brown men of equatorial Sumatra and Java live the blacks of Australia, and the two darkest native races of this continent live near the mouth of the Colorado and that of the La Plata, each of which points is, speaking roughly, about thirty degrees distant from the equator.

The people of the eastern continent, south of the Tropic of Cancer, are for the most part brown or black. Divide what is north of the tropics into two halves by the seventy-fifth parallel of longitude and those to the west are white, those to the east yellow. The inhabitants of the islands of the Pacific vary from the light yellow of the Japanese to the chocolate brown of the Papuans. In America the Haidah Islanders and the aborigines of the neighboring parts of Alaska are almost white, the California and Arizona Indians are dark brown; the Tupis and Guaranis that occupy the valleys of the Orinoco and the Amazons, are yellow; the Peruvians, and the aborigines of La Plata and Patagonia, are brown. The darkest of these, the Charrnas, who lived near the mouth of the La Plata, have sometimes been described as black.

The variations within a short distance are often very striking. There is more dark hair in Wales than in England in the same latitude, but the proportions of dark eyes are reversed. In Wales, in Ireland, and in Brittany, dark hair and blue eyes are very frequently combined, and this has been supposed to be due to Celtic influence. In Ireland, according to Poesche, ninety per cent of the people have bluish-gray eyes. In Teutonic countries blue eyes are more abundant than gray; in Slavonic countries the reverse is the case. In Switzerland the people of the mountains are darker than those of the valleys. In Bavaria the inhabitants of the low-lying country, near the Danube, are the darkest. In Transcaucasia those who live near the Black Sea are blonde, those near the Caspian yellow,—between, there are dark whites. Blondes are found sporadically among a large number of the races of the Northern Hemisphere. That some of the extinct Guanches of the Canary Islands were blonde, is proved by their mummies. If we may trust the recently discovered picture of the mother of King Amenhotep IV., who reigned in Egypt, probably 1700 B.C., she was a blonde. At any rate, fair-haired and light-eyed

people occur at this day in considerable numbers among the inhabitants of the mountainous parts of the Barbary States. The Jews, almost everywhere, present specimens of the blonde and brunette types. The Ghelankis at the south end of the Caspian, the Nestorians of Persia, and the Kurds of the highlands between Turkey and Persia, are partially blonde. Many of the Turcomans who live just east of the Caspian Sea, though Turk by race and language, are blonde; while the Persians to the south and the Tadjiks to the east, though Indo-European in speech, are brunette. Some of the Indo-European tribes in Afghanistan, and on the upper Indus, afford specimens of fair-haired and blue-eyed men. In short we may say that Xanthochroi occur from the Arctic Ocean to the Sahara, and from the Atlantic to the Indus, in greater or smaller numbers, and that occasionally beyond these confines, among the Chinese or Coreans, or even the Indians of Northwest America, individuals may be met with, of pure blood, who exhibit either light eyes or fair hair. For example, the Spanish discoverers of the Thlinkeets of Alaska, expressly note the fact that some of them had blue eyes. "Eran de color blanco y habia muchos con ojos azules." They were of a white color and there were many with blue eyes, says Perez. According to the Abbé David there is to be met with in Sétchuan, one of the northwestern provinces of China, an aboriginal race with light eyes and hair often chestnut or yellowish.

During the last twenty-five years considerable quantities of statistics, relating to the colour of the hair, eyes, and skin, have been collected in various countries. In Great Britain Dr. Beddoe's figures show that the number of blondes increases as we go north; in France the fairest part of the population is in the north and north-east; in Belgium in the north; in Gallicia, a part of Poland, the people are fairer in the north. In Germany the observations made on school children show that Schleswig-Holstein, the northernmost province, is the fairest. The next fairest is not, as might be expected, the next most northerly province, East Prussia, but Pomerania, and the third in the list is Hanover. The geographical position of these provinces naturally leads to the inference that the Scandinavian Peninsula is the seat of the fairest population in the world. The blonde centre is probably somewhere in the southern half of that peninsula, as the Lapps in the north, though partly fair, are partly brunette. In every

direction north, south, east, or west from this central point the proportion of blondes decreases, and that of brunettes increases.

Many theories have been advanced to account for these anomalies. The common explanation is that they are due to race. If so, how is it that we have no aboriginal blondes between the tropics, and no aboriginal blacks north of 35° N. L. It has been thought that civilization produces fairness; but this view is refuted by many facts, the civilized Peruvian Indians, for instance, being darker than their savage congeners on the Amazons. It has been asserted that the upper classes are fairer than the lower; but, though this is the case in Europe and India, the opposite state of things existed in the Sandwich Islands, and still exists in some parts of Africa. A mountain climate has been supposed to produce a light complexion, but the highlanders of Scotland and Switzerland are darker than the natives of the plains of the same countries. Indeed, a pretty good case could be made out for the theory that low, flat countries produce fair complexions. South America, for example, which has no aboriginal negroes, is much less raised above the level of the sea than Africa. But neither is this theory consonant with all the facts.

The explanation has been sought in differences of diet, and it has been conjectured that a superabundance of carbon in the food might lead to the deposit of some of it in the skin. Races then, that live largely upon fat or oily food ought, on this hypothesis, to be darker than others in the same latitude. But there are no facts to show that the Welsh or the Irish live more on carbonaceous food than the English or the Dutch, and yet there is a considerable difference in complexion. Dr. Livingstone thought that a moist climate produces dark skins; D'Orbigny considers it the cause of fairness. Poesche, in his work on the Aryans, seems to consider fairness to be due to the absence from the soil of the elements from which the pigment that gives the yellow, brown, or black shade to the skin is formed.

Darwin, Professor Huxley, M. de Quatrefages and others think it probable that racial distinctions owe their origin to the selective operation of the prevailing diseases of particular climates. Assuming, what is amply supported by facts, that individuals slightly diverging in different directions from the type are constantly being produced, it is obvious that if a dark or a light complexion be correlated with power to resist a particular disease or group of diseases, a white race may, by natural selection, be gradually developed from a coloured one,

or *vice versa*. M. de Quatrefages has suggested that the malarial fevers of Africa have wrought this effect there, and that phthisis has been the agent in the north of Europe. It certainly is the case that the tropical regions of Africa are very unhealthy for whites, and that the Negro dies out north of the parallel of 40° in both hemispheres; but this does not show that both races might not be acclimatized by slow degrees without loss of colour. In other words, no reason has been shown for thinking that it is to the complexion, and not to some other racial peculiarity that the relative immunity from certain maladies is due.

Of these various views, I am inclined to hold that that of D'Orbigny and Schomburgh is most in accordance with the facts. Europe which is the seat of the white man is the moistest of the continents; the fairest of North American Indians live on the humid coast and islands of Southern Alaska and Northern British Columbia; where there are unbroken forest regions in South America, and therefore a comparatively moist climate, the aborigines are yellow; where prairies and droughts prevail, they are brown. As compared with Hindostan, Farther India is moist, and its inhabitants are less sombre in hue. The brown men of Sumatra, Borneo, Java, and Celebes inhabit forest-covered, and therefore comparatively humid islands, the black races of Papua and Australia roam over grass-clad plains, whose existence proves the relative dryness of the air. But neither is this hypothesis in accord with all the facts. The co-existence of races of different hues in India, and of the brown Malays, and black Negritos in the Philippines and Malacca, cannot be explained by it. The west coast of Great Britain is incomparably the damper, but yet the inhabitants of the east are decidedly the fairer.

Some portion of these, and similar facts, may be explained by supposing that certain introduced races have not become completely acclimatized. It might, for example, be held that this is the cause of the relative fairness of the higher castes in India. It might too, be held that if many thousands of years were allowed, the blonde inhabitants of Great Britain and Ireland would disappear, and be replaced by a homogeneous race of dark whites, similar to the pre-Celtic inhabitants of those islands. There is some evidence tending to support this view. In particular, I may mention Dr. Beddoe's observations on the colour of the eyes of women, from which it appears that the proportion of dark-eyed women in England is growing larger.

Another explanation of some of these facts, that possesses a certain degree of probability, is, that difference of colour in the same country is due to mode of life. It may be maintained that the Samangs of Malaca, and the Aëtas of the Philippine Islands are darker than the other inhabitants, because the poorness of their dwellings, and their consequent practically constant exposure to sun or wind, renders it an advantage for them to be dark.

Another explanation to which I shall make reference later, is that humidity is probably not the sole climatic influence that operates.

I may say here that I do not attach importance to the direct influence of climatic conditions. It is, indeed, a matter of common observation that these produce considerable effects on the individual. Pruner-Bey, for example, states that he has noticed that "the European acclimated in Egypt acquires after some time a tawny skin, and in Abyssinia a bronzed skin; he becomes pallid on the coast of Arabia, cachectic white in Syria, clear brown in the deserts of Arabia, and ruddy in the Syrian mountains." But there is no proof that these cutaneous changes are inherited. If, however, it can be shown that a particular kind of skin is better than others for resisting the deleterious influences of a given climate, it stands to reason that those members of a race whose skins vary in the direction of this type, will, in each generation have the best chance of surviving and begetting children, and that by the continued increment of successive variations in the same direction, the skin and the climate will ultimately be brought into accord.

The skin consists of two layers: the inner, dense and fibrous, furnished with blood vessels and nerves, called the derma or true skin; the outer, horny, nerveless and bloodless, called the epidermis, cuticle, or scarf-skin. The cells which compose the latter originate in the *rete Malpighii*, its lowest part, are gradually forced outward by new cells and finally exfoliate. In some of these epidermic cells a pigment is found which varies in different races, but always contains a yellow element. The hue of the skin does not depend on this colouring matter alone, but is a compound effect resulting from the white of the dermis, the red of the blood in the minute vessels near the surface, the colour and quantity of the pigment, and the thickness of the cuticle. Where the cuticle is thick, the colour of the pigment will predominate over the other elements on account of the greater depth of pigment-cells. Where it is thin, and the colouring

matter light, the tint of the skin will be much affected by any change in the supply of blood to the capillaries at the surface of the body. This is the reason why the whites alone can turn pale and blush.

Closely related to the pigment of the skin are the colouring matters of the eye and hair. Dark-skinned people usually have black eyes and hair; fair hair and blue eyes are seldom found except in conjunction with a fair skin; and the eyes and hair of albinoes, in whom the pigment of the skin is wanting, are likewise destitute of colouring matter. The pink hue of their eyes is due to minute blood-vessels, whose colour is masked in ordinary organs by the pigment of the iris.

It is noteworthy that the colouring matters of the epidermis and the iris serve a very important purpose; they protect the tender underlying parts from the injurious effects of too much heat and light. Albinoes everywhere find it necessary to protect their skins and eyes from the action of the sun's rays. In warm countries they seldom go out except at night There is this difference between them and other men, that long-continued exposure to the sun, which ordinarily develops a condition of the skin capable of resisting its rays, does not do so in their case. It may here be remarked that, the greater the quantity of the pigment, the less transparent will the epidermis be, and the more effective will it be as a protective agency. On the contrary, the smaller the quantity, the greater the transparency, and the less the protection.

Under certain circumstances the exposed parts of our bodies become tanned, that is to say, an increase in the colouring matter which they contain takes place. Dark whites tan brown, fair whites tan red. The change is caused by the influence of the sun or wind, and is obviously protective in its character, as the unpleasant feelings which result from the first exposure do not recur when we have become thoroughly tanned. This fact, I believe, contains the key which explains the distribution of colour among the races. The climate, or the mode of existence of most races, renders it an advantage to them to begin life more or less deeply tanned.

As an excretory organ, it is the function of the skin to discharge water, carbonic acid and urea—the first in large, the others in small quantities. Perspiration, or the excreting of water with some saline matter in solution, is effected in two ways. In the first place, sudoriparous glands, imbedded in the true skin, secrete sweat from,

the blood. This is conveyed to the air by minute ducts passing through the epidermis. It is obvious that, the less transparent the outer skin, the less light and heat will be transmitted to excite these glands into activity. In the second place, there is a continual transudation of sweat from the minute vessels of the surface of the body through the epidermis at every point. The thicker or more oily the scarfskin, the less will the amount of this transudation be. If it be both thick and oily, as in many dark races, the quantity transuded will be reduced to a minimum; if it be thin and not oily, as in the fairest members of the white race, transudation will be copious.

The amount of transuded sweat depends, however, not only on the thinness of the cuticle, but also on the degree to which the air in contact with the body is saturated with moisture; for there is a limit to the quantity of vapour which the air can absorb. This limit varies with the temperature, warm air absorbing more than cold. It is also to be remarked that perspiration relieves the body of heat as well as of moisture, and that a dark skin may serve as a means of radiating heat in climates in which a large loss of moisture is a disadvantage. Such being the nature of the skin, I now proceed to inquire what kind of it will best suit particular regions. For this purpose climates may be classified as—

I. Arctic.
II. Moist temperate.
III. Dry temperate.
IV. Moist tropical.
V. Dry tropical.

1. When the skin is exposed to great cold, perspiration by transudation is accelerated. The frosty air, being raised many degrees in temperature by contact with the body, becomes very dry, and greedily drinks in its moisture. At the same time the body loses not only the heat which the air carries off, but also that which is rendered latent by the evaporation of the sweat. As a protection against the injury which a too rapid loss of perspiration and heat may inflict in an arctic climate, a thick integument is desirable. It is, I believe, the fact that arctic races have thick skins. At any rate M. de Quatrefages says that cases of dry rough skins occur most frequently among the polar tribes. This I take to be a result of the thickness of the

cuticle, just as, on the older parts of a tree, I take the roughness of the bark to be a consequence of its thickness.

But why should the eyes, skin and hair of the Polar tribes be darker than those of the blonde Europeans who live to the south of them? I suggest that it is on account of their perpetual or almost perpetual snows. It is a well-known fact that the rays of the sun reflected from the Arctic snows tan Europeans and produce snow-blindness in them. From these effects the natives enjoy, I understand, comparative immunity, which I think it fair to attribute to the colour of their skins and eyes. The hair, being anatomically a part of the skin, varies with it in colour.

II. By a moist temperate climate I mean one occurring in a temperate zone in which the air constantly contains a large amount of moisture. Humidity does not to any considerable extent depend on the amount of the annual rainfall. The annual rainfall of London is twenty and one-half inches, that of Toronto twenty-seven inches; yet the air of the former place is incomparably more humid. Countries in which the air is generally moist are distinguished from others in the same latitude by the limited range of the thermometer. This is due partly to the fact that the vapour of water cannot be so rapidly heated or cooled as air, and partly to the check which the presence of haze, mist, or cloud in the atmosphere puts upon radiation. A moist temperate climate is also warmer than others in the same latitude, for it owes its existence in every case to breezes from warm seas. Breezes from cold seas cannot produce a true humid temperate climate, because when they strike the land in summer they will be raised in temperature and rendered dry.

In humid temperate climates, since the rays of the sun, falling obliquely through a moisture-laden atmosphere, lose much of their light and heat, much pigment is not needed. The vapour-clogged air does not facilitate perspiration, therefore a thin epidermis is desirable. The combination of a thin epidermis with little pigment will give a white complexion.

The best example of a moist temperate climate is furnished by the countries lying around the North and Baltic Seas, which are apparently the native land of Huxley's Xanthochroi. The central part of this district, namely Southern Sweden, is probably the place where there are most blondes. But Great Britain, though more humid,

is less blonde than Germany Denmark and Sweden in the same latitudes, and in Great Britain and Ireland, though the humidity increases, the fairness of the population diminishes as we go west. Two explanations of this difficulty besides that of race, which last from the point of view of this paper is no explanation at all, have suggested themselves to me. One is that, as wind is a tanning agent, it may possibly be the case that Ireland is more windy than England, and England than Denmark and North Germany. But I have no facts to either bear out or overthrow this hypothesis. The second is that the fairest type of blonde is produced by the humidity caused by evaporation from fresh or nearly fresh water. A glance at the map shows that the greater part of the blonde area is low and swampy, and that the eastern and fairest part of it derives much of its vapour from the half-fresh Baltic Sea. This hypothesis is supported to some extent by the case of Mingrelia, the westernmost part of Transcaucasia, and the source whence the unspeakable Turk obtained the blonde beauties with which he used to stock his harem, the moisture of this country being derived from the half-fresh waters of the Black Sea.

III. By a dry temperate climate I mean one occurring in a temperate zone in which the atmosphere is usually dry. Countries in which this climate prevails are distinguished from others in the same latitude by the greater range of the thermometer. Their summers are hot and their winters cold. As a protection against the greater heat and brightness of the sun, a less transparent cuticle than that which serves the purpose in humid temperate regions is necessary. To prevent the too rapid withdrawal of the fluid contents of the capillaries by the dry air a thick epidermis is required. The combination of a thick cuticle with a quantity of pigment such as will satisfactorily modify the intensity of the sun's rays will produce various shades of yellow and brown.

A good example of a dry temperate climate is furnished by the prairie regions of North America. The aborigines of this district were brown with the exception of the Mandans, among whom a curious kind of albinism seems to have been astonishingly prevalent.

IV.—By a moist tropical climate, I mean one occurring in or near the torrid zone, in which there is no dry season. In such a climate vegetation will be luxuriant all the year round, and man will live in the shade of dense forests, in a steaming and enervating

atmosphere, where the temperature will be high, but will vary little. Though the rays of the sun will descend vertically upon him, yet their power will be diminished by the vapour contained in the air, and he will not need so dense a pigment to protect him as the inhabitants of other tropical regions. Add to this, that a thin epidermis will facilitate the perspiration which a moisture-laden atmosphere tends to check, and we come to the conclusion that the natives of such countries will be distinguished by comparatively fair complexions.

As an example of a moist tropical climate we may take the valley of the Amazons and point to the fact that its aborgines are lighter in colour than those of rainless Peru.

V.—On the contrary in a rainless tropical climate, or in one with a well-marked dry season, the rays of a vertical sun will continually or for considerable periods descend in all their power, and the densest pigment and the thickest scarfskin will be needed. In rainless Nubia, for example, the inhabitants, whether of Semitic, Hamitic, or Negro stock, are alike black.

The part of Africa south of the Great Desert, will exemplify the case of a tropical climate with a dry season. This immense region consists essentially of a strip of low coast land, and an immense level central depressed surface with a more or less elevated rim surrounding it. The inhabitants of the coast and the central depression are very black, those of the rim lighter in color. Dr. Livingstone attributed this to the greater humidity of the lower regions. But it is obvious from theoretical considerations that the elevated rim must be more humid than any other part of the continent. During the dry season, the sea-breezes, when they strike the coast, will be raised in temperature and consequently deposit no moisture until cooled by being forced upward when they come against some elevated land. The meterological observations of travellers show the facts to accord with this view.

There are black men in Africa, in India, and in Australia and some of the adjacent islands, because these countries all have long, pronounced dry seasons. Owing to the peculiar formation of the continent of America, its tropical regions are, for the most part, very humid, and consequently very dark natives are found within them only in Peru, which possesses a very dry climate.

An immense number of facts might be adduced in support of this theory; but there are some which it fails to explain. Nevertheless,

so great is the mass of evidence showing that humidity has been an efficient agent in producing fairness that I must hold to the belief that there is something in the views which I have just attempted to express. Yet, whatever may have been the causes which have given rise to the diversity of complexion that exists among mankind, it is clear that the colour of each race is now so fixed, that climatic influences change it very slowly. Neither the negro nor the white man on this continent has varied much in the direction of the Indian. Both white and negro have, however, been here only a few centuries. A much longer time has elapsed since the populous and frozen North sent her barbarian hordes across Rhene and the Danaw to destroy the Roman empire, but yet, wherever we have historical reasons for expecting to discover traces of German blood, we find a relatively large number of blondes. The land of the conquered countries, as a matter of course, fell into the hands of the German invaders, and from them sprang a new aristocracy. It is remarkable that, to this day, the nobility and gentry of every part of Christian Europe are exceptionally fair. The conquerors naturally settled in the greatest numbers in the most fertile parts; it is precisely in the mountains and the other comparatively infertile districts that the brunette whites are most numerous. In Switzerland, for example, there is a greater percentage of blondes in the more level parts in the centre, than in Mount Jura on the west, or the Rhaetian Alps on the east. Similar facts meet us in England and France. Wherever there is reason to believe that there has been a settlement of Germans or Scandinavians, the complexions are to this day comparatively fair. The nine centuries that have elapsed since the Northmen settled in Normandy have not made their descendants as dark as the neighbouring Bretons; nor have thirteen hundred years made the West Saxon of Somerset and Gloucester similar in complexion to the Welshman of Glamorgan and Caermarthen.

Facts like these have led many ethnologists and anthropologists to conclude, perhaps, too hastily, that colour is the least variable of all the characters that mark a race. This, if true, leads with considerable probability, to the hitherto little noticed, but most important conclusion, that the original seat of the Aryan race was in Europe, and on or near the shores of the Baltic Sea. I propose now to ask your attention while I show how this conclusion follows, and very

briefly enquire whether what is known from other sources about the Aryans is consonant with it.

It is well-known that philological investigation has established that nearly all the European, and some of the more important Asiatic languages are descended from a common source, and that these are at the same time related to each other in such an intimate manner and so widely different from all other languages, that scientific men feel justified in setting them apart in a family by themselves. To this family belong the Celtic, Teutonic, Slavonic, and Romance languages, together with the Greek, the Armenian, the Persian, the Hindi, and others. The language whence all these have sprung is the Aryan, and it follows as an almost necessary corollary, that wherever an Aryan language is now spoken, there must be some admixture, however slight, of Aryan blood. There is therefore a community of speech between all Englishmen and all Hindoos, accompanied by a community of blood between some of each race.

With the exception of the Aryans of India, the Aryan races are white, and, as the sacred books of the Hindoos represent their ancestors as an intrusive race in conflict with dark aborigines, it is fair to assume that their present colour is due to an admixture of non-Aryan blood, this postulate of course being always granted that climate has no appreciable effect upon the colour of a race that has once established for itself a separate and distinct type. But as has already been stated, there are two white races, the brunette and the blonde. These are intermingled in various proportions in almost every country in which whites are to be found. We have seen that the blondes are most numerous on the shores of the Baltic and North Seas, and that in whatever direction, whether north, south, east, or west one recedes from these shores, the proportion of brunettes increases. Now, assuming that racial peculiarities are unchanged, except by intermixture, were the original Indo-Europeans a blonde or a brunette race, or one composed like most of the modern Indo-European nations of an intermixture of the two?

The following facts seem to show that the original Indo-Europeans must have been either purely or largely blonde. There are only three Indo-European races, the Hindoos, the Persians, and the Armenians, in which no blondes occur, and these occupy countries too far south to be the original home of the race, since a variety of evidence shows that it must have been situated in a tolerably cold climate.

Among all the others blondes occur in greater or smaller proportions. In western Europe, wherever we have a large proportion of dark whites, we have a good deal of evidence to show that there has been a mixture of the Indo-Europeans with the previous occupants of the soil. In Italy there were, in historic times, Etruscans and Ligurians, one, or both of which races were non-Aryan. In England, France, and Spain the evidence is strong that supports the theory that there is still a large amount of Iberian or Basque blood in the population.

Now, if the original Aryans were blonde it is natural to look for their seat where there is to-day the largest fair-white population, that is, in the neighborhood of the Baltic and North Seas. Here, as a matter of fact, we find the Lithuanians, whose language of all living languages most closely approximates to the original Indo-European. Our Aryan ancestors were pre-eminently a cattle-rearing race, and there is a strong probability that the domestic cattle of Europe are descended from its native wild stocks. As they knew something of the sea, and apparently nothing of the camel or tiger, it does not appear probable that Eastern Turkestan was their original home. Western Turkestan, though bordering on a sea, is precluded by the infertility of its soil, and its utter unsuitability to the kind of life we know the Aryans must have led. It is probably true that the Persians and Hindoos lived together at one time in Eastern Turkestan, but that does not prove that they had not come there from some other place. Indeed, the hypothesis that Turkestan was the original seat of the Aryans, seems to have no better foundation than the belief that the west has been peopled from the east. It may be true that the first men who lived in Europe came from Asia. But that must have been at a period antecedent even to the very remote date at which the Aryan race developed its special characteristics. Within the historical period, at any rate, there have been as many advances of Europeans into Asia as of Asiatics into Europe. At the very beginning of written history we hear of a Persian invasion of European Russia in retaliation for a previous invasion of Persia by Scythians from Russia. After the Persians' failure to establish themselves in Europe, the Greeks established themselves in Asia and hellenized it more or less completely to the head waters of the Ganges. The reaction came when the Huns and Saracens penetrated to France. From the battle of Tours, in which Charles the Hammer turned back the Mohammedans, to the siege of Vienna, two hundred years ago,

the contest between the west and east went on with varying results; but since John Sobieski drove the Turks out of Austria the tide has turned. The Turk is on the eve of being driven out of Europe, half of Asia belongs to Russia and England, and European ideas and blood are everywhere changing the character of that continent. As far as history informs us, population has moved as often from the west to the east as from the east to the west.

The first opponent of the Asiatic origin of the Indo-Europeans, as far as I know, was one Schulz, who published a book on the source of the German race in 1826. The next considerable protest came from Omalius d'Halloy, who objected mainly on physiological grounds. He was followed by that eminently original thinker and suggestive writer, R. G. Latham, whose objections were philological. His argument is very clearly put in the following words:

"Where we have two branches of the same division of speech separated from each other, one of which is the larger in area and the more diversified by varieties, and the other smaller and comparatively homogeneous, the presumption is in favour of the latter being derived from the former rather than the former from the latter. To deduce the Indo-Europeans of Europe from the Indo-Europeans of Asia, in ethnology, is like deriving the reptiles of Great Britain from those of Ireland in herpetology."

Since he wrote these words his views have been adopted by a number of Germans, among whom may be mentioned Geiger, Cuno, and Benfey. The two former of these, with perhaps some excess of patriotism, place the cradle of the Indo-European race in the heart of Germany. Oscar Peschel places it in the Caucasus, but this is evidently a compromise. Poesche places it in the Rokitno Swamp in the neighbourhood of Pinsk in West Russia. There is here about the upper waters of the Dnieper an immense swampy region, which is said on the authority of a Russian traveller, Mainow, to be remarkable on account of the general lack of colour in all organic nature. Cases of albinism are very frequent, the horses are almost all gray or light yellow, the leaves of the trees are pale, and everything is dull and colourless.

My conclusions are:—

1. That the causes which in early times developed the existing differences of colour were partly or wholly climatic.

2. That two of these were distance from the equator and moistness of the air.

3. That there were other causes which have not been discovered.

4. That the colour characteristics of existing races change very slowly, if at all, under the influence of new climatic conditions.

5. That the agreement of two races in colour is no proof of community of origin.

6. That the chief, perhaps the only point of origin of the blonde race was in Northern Europe.

7. That the Indo-Europeans were largely blonde, and that their original home was near the Baltic Sea.

After the address, Prof. Ramsay Wright, of University College, exhibited some new microscope objectives, by Gundlach, of Rochester, U. S., and by Zeuss, of Jena.

SECOND ORDINARY MEETING.

The Second Ordinary Meeting of the Session 1883-1884, was held on Saturday, November 10th, in the lecture-room, the President in the chair.

The minutes of last meeting were read and confirmed.

The following gentlemen were balloted for, and duly elected members.

Alan Macdougall, C. E., F. R. S. E.; Messrs. John McAree, Harry Walker, Frederick T. Butler, James Jardine, G. H. Robinson, M.A., J. M. Clark, B.A., A. S. Johnston, B.A., T. G. Campbell, B.A., John Squair, B.A., H. R. Fairclough, B. A., J. Warren Reid, B. A., J. C. Robertson, B. A., Capt. Gamble Geddes, A. D. C.

The following donations and exchanges received since last meeting, were announced :

1. Minutes and Proceedings of the Institute of Civil Engineers, London, Vol. 74. Series 1882-'83, part 4. Brief Subject Index to Minutes and Proceedings of the Institute of Civil Engineers, vols. 59 to 74. Series 1879-80 to 1882-83.
2. Transactions and Proceedings of the New Zealand Institute for 1868, 1872, 1873, 1874. Vols. 1, 5, 6, and 7.
3. The Canadian Entomologist, vol. xx. No. 9 for September, 1883.

A paper entitled "The Literature of English-speaking Canada" was then read by C. Pelham Mulvany, M.A., M.D., T.C.D. Among the writers reviewed were Prof. Watson, Mr. Le Sueur, Mr. Grant Allen, Prof. Dawson, Mr. R. W. Phipps, Dr. Canniff, Principal Grant, Mr. Charles Dent, Mr. J. E. Collins, Mr. George Stewart, Mr. C. G. D. Roberts, "Seranus," "Espérance," and Mr. P. Thompson. In discussing the paper Mr. Geo. Murray noticed the omission of the names of Dr. Rolph, Mr. Charles Lindsay, and especially the late Mr. W. J. Rattray.

THIRD ORDINARY MEETING.

The Third Ordinary Meeting of Session 1883-84 was held on Saturday, November 17th, the President in the chair.

The minutes of last meeting were read and confirmed.

Mr. Henry P. Gisborne was elected a member.

The following exchange was announced as received since last meeting :

Proceedings of the Royal Geographical Society, N. S., Vol. V., No. 11, for November, 1883.

Mr. W. A. Douglas, B.A., then read a paper on "LAND AND LABOUR," in which a distinction was drawn between property in land and property in other things. We had adopted the system of land tenure that prevailed in Western Europe, and by this system the greater part of society were practically deprived of any right to the surface of the earth. Of two settlers in the North-West, for example, one secures a section which becomes a farm, the other a section which becomes the site of a town ; after twenty years the farm sells for $30 or $50 an acre, the town site for $10,000 or $100,000 an acre. It is more than likely that the owner of the town-lot had done less toil for his reward than the farmer. There was a great distinction between trade in land and trade in other commodities. A man or a number of men take a piece of worthless rock, they subject it to smelting, rolling, etc., and

convert it into a knife or a steam-engine. Here they have added to the utility and have increased wealth. They have furnished a service. Every addition to that utility has been at the cost of muscle and brain. The owner of a piece of land that eventually becomes the site of a town can show no service for his demands. The land of the globe is in fixed quantity, while the populatiou demanding land is not fixed, but on this continent is rapidly increasing. In conclusion Mr. Douglas said: "If I have represented with any approach to truth the effects of our present system of land tenure, then the conclusion must be inevitable that we are acting with wicked recklessness in our new territories in alienating with a haste as though to retain possession would be equal to a plague or a deluge. A second conclusion is that our methods of taxation are radically wrong. Instead of taking revenue from the rewards of idleness, we are now doing everything in our power to diminish the reward of labour, and actually impose taxes as penalties to prevent the extension of that system of exchange by which labour seeks to produce its utmost by resorting to the best suited locations."

An animated discussion then followed, in which Dr. Mulvany, Mr. William Houston, Mr. George Murray, Prof. Ellis and Mr. Creelman took part.

FOURTH ORDINARY MEETING.

The Fourth Ordinary Meeting of the Session 1883-84 was held on Saturday, November 24th, the President in the chair.

The minutes of last meeting were read and confirmed.

Mr. J. E. Collins was elected a member.

The following exchanges were announced:

1. Science, vol. 2, No. 41, for November 16, 1883.
2. Monthly Weather Review for October, 1883.
3. Journal of the Anthropological Institute, vol. 13, No. 2, for November, 1883.
4. List of Members of the Anthropological Institute, corrected to November, 1883.

Mr. D. A. O'Sullivan, M A., then read a paper entitled :—

OUR FEDERAL UNION,

Of which the following are extracts :

I think I shall be within the spirit and letter of the constitution of this Institute in discussing the Federal Union of Canada, in the way I propose to myself in this paper. The science of speculative politics, in which the defects in any constitution may be discovered, and remedies proposed for their removal, is probably undesirable except in purely political societies. At all events it is not the subject here proposed for consideration. * * * I shall draw attention simply to the fundamental law of our Canadian Confederation, and confine myself to our constitutional existence as it is, and not speculate as to what it might have been, and be better than it is. * * *

To say that there has been a Federal Union in Canada—using the words in their strict sense—is in my opinion incorrect. The provinces which form that Union in Canada are not and were not sovereign states – they were not even possessed of reserved powers in legislation—they strictly were not relatively independent colonies of the Empire. The States of the Union, before their admission into the Union, were colonial possessions, and they retain to this day the reserved powers of legislation. Even they are not sovereign states, though it took a war to decide that point. They are, however, much nearer to the possession of sovereign power than the provinces of our Federation. * * *

It will be seen from an historical glance at the United States what took place in this respect. Their *quasi* sovereign states, in the year 1777, bound by a compact which was called a confederation, soon learned how useless was such a compact, which had no executive force, and out of which the members might come and go at liberty. Accordingly a convention of some ten years later met and arranged on the terms of an indissoluble union, from which, having once entered, secession was impossible without resorting to means outside of the proposed terms or constitution. Nine States came in and adopted it, and in a short time every State of the old and obsolete coufederation, every old colony of Great Britain was ranged under one flag and as one nation. * * *

In the British North American Colonies confederation has been talked of since the first year of this century. In 1800, 1814, in 1822, in 1825, in Lord Durham's time, in 1859 and in 1864, there have been projects of union. Of the conventions of this latter year in Quebec and Charlottetown, it will be sufficient to say that three Provinces undertook finally to deal with the question of a federation. These were not pretended to be sovereign in any sense and not at all in the sense in which the present Dominion may be said to be sovereign. These Provinces took all their rights as colonies in their hands and said in effect to the Mother Country, "We resign our present charters; we have agreed to a new state of things; wipe out the past, and ratify the arrangements we propose to make for the future." The old colonies then passed away, and in their place came one new colony of the Empire, with one parliament to make laws for the peace, order and good government of its people. The charter provides for the government of Canada. The new Canada was then divided up into as many Provinces as there were formerly colonies, with the same or probably the same geographical boundaries. The re-casting of the new Provinces of Canada from the aggregated former colonies of the empire is something not to be lost sight of—their *status* has been entirely altered—their powers of legislation are limited and the reserved powers taken from them—their ability to secede from the union out of the question—their rights to be considered sovereign states entirely untenable on any legal ground. The concession of legislative powers to the central government was done in a manner totally different from what was done in the United States, and it would be a confusion of language to speak of the present provinces conceding powers to any government before they possessed any themselves. The interposition of a statute like the Act of Confederation of 1867 between the old colonies and the new provinces may not appear of great moment to persons other than lawyers; but nevertheless it is as material as any document can be which regulates and governs the parties affected. It is like the partnership deed or joint stock charter of a new firm or company—it is to be looked to in the first instance—it is that which gives us such rights and privileges as we now possess; it is the law before all others, except imperial legislation, that must be regarded and obeyed. * * *

With us the Provinces were merged into the new Dominion—gave up their names and their charters, and submitted to be governed by one parliament at Ottawa. They were re-cast, re-created and formed into Provinces of the Dominion—no longer separate colonies of the empire, but constituent elements of the new larger colony. The powers given to the Provinces were enumerated powers—many of their ancient rights were gone or become obsolete, and henceforth they were new creatures, supreme in their own local rights, but having no capacity to increase their own stature by one cubit. * *

The main feature of every Federation is how far its constituent provinces approach to sovereign States. The autonomy of our Canadian provinces is perhaps the lowest in the scale of power that can be exemplified in history. The list of subjects assigned to the Central Government at Ottawa is fully more than double that assigned to the Provinces, and every unenumerated matter goes to swell the central list. And not only that, but the larger list embraces the important matters. When the autonomy of a Province is spoken of, or the home rule of a Province asserted, it must be with large qualifications. The home rule of an obedient wife to her husband is not an inappropriate comparison but like all other comparisons is not to be pursued too far. * * *

For good or for evil, so far as our written constitution goes, the people of Canada have agreed to be governed by one Parliament—to have laws made for the peace, order and good government of Canada —but for convenience sake the Provinces have the exclusive right to legislate on certain defined subjects. The legislation is kept under a species of control in the Courts, which is also exercised over Dominion legislation, and the other the veto power of the Governor General of Canada. The Lieutenant-Governor of each province is an official of the Government of Canada, and is sent to preside over the local Legislatures with certain powers over the legislation and with executive control. The subordination of the Provinces to the Dominion is provided for—at least on paper, and their whole duty is the transacting of the Local government assigned to them. The provinces are independent of each other, but are unable to enter into any engagements other than the constitution provides for them. This is far from being in the position of *quasi* independent states, and indeed inter-provincial dealings are removed much further than before the union of 1867. * * *

So much for the Legislative power. The judicial power is totally different from what obtains in England. In the main—except as to certain powers of the Supreme Court at Washington it is analogous to the judicial power in the United States. A judge in England cannot ignore a statute so long as it is on the books. It binds him—he may evade it or misinterpret it, but before the Constitution he has no power to query it. Such is not the case here or in the United States.

With us, as with them, the Constitution is the basis of legislative authority; it lies at the foundation of all law, and is a rule and commission by which both legislators and judges are to proceed. If the legislatures transgress their constitutional bounds the courts must correct them. But the judiciary has no control over legislature, and no power whatever to question its purpose or animus so long as such legislation is kept within its defined limits. The judiciary is, therefore, not a subordinate but a co-ordinate branch of the government of this country. It may keep the executive even within its authority by refusing to give the sanction of law to whatever it may do beyond it, and by holding the agents and instruments of its unlawful action to strict accountability.

A judge in a Division Court, as well as a judge in the Supreme Court, may be bound to ignore a statute, if not passed by the proper Legislature or Parliament. Every act of any of our legislatures repugnant to the Constitution is absolutely void, and cannot become law of the land. There is a presumption in favour of its validity, however, until the contrary is established.

The executive power in Canada is peculiar and merits a remark. Whilst the legislative powers of the Provinces and the Dominion are sharply defined, and whilst the judicial or administrative powers are little capable of creating a difference of opinion, it is impossible to say that the Act of 1867 is "not conflicting," or at least embarrassing in respect of the executive. In the British Constitution the sovereign is the apex of authority; the King or Queen theoretically summons the Parliament, which makes or is responsible for all the laws in the realm—appoints the judges who administer these laws, and the executive authority is vested in her. The same Queen in Canada is the same power, and summons the Parliament at Ottawa, appoints the judges as a general rule, with one trifling exception, and the executive government and authority of and over Canada is vested in her. This,

of course, applies only to the Federal Government, but from other expressions and from one express section in the same Act, several of the Provinces claim that Her Majesty is a necessary element in their Provincial Legislatures; that she is the executive in the Provincial Legislatures. These Provinces are Ontario, Quebec, Manitoba and British Columbia, and they use the same forms *mutatis mutandis* of enacting laws as are used at Ottawa or at Westminister. * * *

It is conceded that the Queen has no immediate power over Provincial Legislation, as the veto on it must come from Ottawa and not from England. When, therefore, Her Majesty passes an Act in the Provinces referred to, Her Majesty's representative at Ottawa may disallow it—a proceeding likely to endanger the well-known doctrine of principal and agent, but from which happily no serious results have yet happened. * * *

I have now called attention to the three great divisions of government—the executive, the judicial and the legislative. In the latter two of these we resemble the Constitution of the United States—in the former and as to the Dominion Parliament generally, we offer an example of a reduced copy of the British Constitution. We labour under the disadvantages of every people living under a written constitution—defined, limited and inflexible—but we have the advantages which a certain amount of definiteness always affords. We have not been an easy people to govern in the past, and it is likely that we will be no better in the future.

The inhabitants of the Dominion scattered from ocean to ocean—men of different countries and languages—different religions and races—are difficult to govern consecutively in the same way for any great length of time. Six changes we have had since Quebec fell, and our ablest men will now tell you that the next few years are going to decide largely the fate of the Dominion.

It may be impossible to keep in union elements that are ill-assorted or antagonistic, but the continued existence of Canada as a Federation will be due to the united good sense of the whole people rather than to the absence of defects of any constitution binding them together."

In the discussion which followed Mr. George Murray, Mr. William Houston, Mr. Alexander Marling, and Mr. William Anderson took part.

FIFTH ORDINARY MEETING.

The Fifth Ordinary Meeting of Session 1883-84 was held on Saturday, December 1st, 1883, the President in the chair.

The minutes of last meeting were read and confirmed.

The following exchanges were announced:

1. Proceedings of the Royal Colonial Institute, Vol 14, 1882-83.
2. Journal of the Linnean Society of London.
   Botany, Vol. 19, No. 122.
   " Vol. 20, Nos. 123 to 129.
   Zoology, Vol. 16. Nos. 95 and 96.
   " Vol. 17, Nos. 97, 98, 99, 100.
   Proceedings of the Linnean Society from November, 1880, to June, 1882.
   Lists of the Linnean Society for October, 1881, and October, 1882.
3. Science, Vol. 2, No. 42, for November 23, 1883.
4. Catalogue of Canadian Plants, Part 1, Polypetalæ, by John Macoun, M.A.
5. Minutes and Proceedings of the Institution of Civil Engineers, Vol. 57, Session 1878-79.
6. Science Record, Vol. 2, No. 1, Nov. 15, 1883.
7. Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils, September, 1883.
8. Journal of Speculative Philosophy, Vol. 17, No. 3.
9. Report of the Smithsonian Institution for 1881.
10. Schriften der Physikalisch—ökonomischen Gesellschaft, zu Königsberg, for 1882, first and second parts.

Mr. J. Herbert Mason then read a paper on "Transfer of Land." The object of the paper was to call attention to the cumbrous and expensive character of the present method of land transfer, and to urge the adoption of the so-called "Torrens System." The following members took part in the extended discussion which followed: Mr. Geo. E. Shaw, Mr. J. C. Hamilton, Mr. Geo. Murray, Mr. W. A. Douglas, Mr. D. Blain, Mr. J. A. Patterson, Mr. Jas. Bain, jun., and Mr. Oliver Howland.

THE SIXTH ORDINARY MEETING.

The Sixth Ordinary Meeting of the Session. 1883-84 was held on Saturday, December 8th, 1883. The First Vice-President, Mr. George Murray in the chair.

The minutes of last meeting were read and confirmed.

Mr. M. McLaughlin was elected a member.

The following exchanges were announced :

1. The American Journal of Science, Vol. 26, No. 156 for December, 1883.
2. Journal of the Franklin Institute for December, 1883.
3. The Canada Practitioner, December, 1883.
4. On the Osteology and Development of Syngnathus Peckianus, (Storer) by J. Playfair McMurrich.
5. Journal of the Royal Dublin Society, Vol. 2, 1858-'59.
6. Sitzungsberichte und Abhandlungen der Naturwissenschaftlichen Gesellschaft "Isis" in Dresden, Januar bis Juni.
7. Science Vol. 2, (No. 43, November 30, 1883.)
8. Constitution and By-Laws of the Chicago Historical Society, 1882-83.
9. Second Annual Report of the United States Geological Survey for 1880-'81.
10. Twelfth Annual Report of the U. S. Geological and Geographical Survey of New Territories; a Report of the Progress in the Exploration of Wyoming and Idaho for 1878 by F. C. Hayden; U. S. Geologist, Parts I and 2.
11. Maps and Panoramas to the above.
12. United States Geological Survey, Monograph 2; Territory History of the Grand Cañon District by Clarence C. Dutton.
13. Atlas to accompany the same.
14. Bulletin of the U. S. Geological Survey, No. 1.
15. Magazine of American History of December, 1883.
16. The Scientific Transactions of the Royal Dublin Society, Vol. I, (Series 2), Parts 15, 16, 17, 18, 19 for January, February, August and November, 1882.
17. Scientific Proceedings of the Royal Dublin Society, Vol. 3, (N. S.), August, 1882, Part 5.
18. Verhandelingen der K. Akademie Van Wetenschappen, Twee en Twintigste Deel.
19. Verslagen en Mededeelingen der K. Akademie Van Wetenschappen, Afdeeling Natuurkunde, Tweede Reeks, 17th Deel, Parts 1, 2, 3.
20. Jaarboek Van de K. Akademie Van Wetenschappen, Amsterdam, 1881.
21. Memoirs of the Geological Survey of India, (Palæontologia Indica,, Series 10, Vol. 2, Part 5.
22. Jahrbuch der K. K. Geologischen Reichsanstalt, 1883, Band 33, Numbers 1, 2, 3, January to September, 1883.
23. Oversigt over det Kongelige Danske Videnskabernes Selskabs, Forhandling og dets Medlemmers Arbejder i Aaret, 1882, No. 3, 1882, and No. 1, 1883, Kjobenhavn.
24. Mémoirés de la Société Royale des Antiquaires du Nord, Nouvelle Série, 1882-83, 1884 Copenhague.
25. 22 und 23 Berichte uber die Thätigkeit des Offenbacher Vereins für Naturkunde vom 29 April, 1880, bis 4 Mai, 1882, Offenbach a. M., 1883.
26. Tillaeg til Aarboger for Nordisk Oldkyndighed og Historie, 1881, Kjobenhavn, 1882.
27. Papers, Proceedings, and Report of the Royal Society of Tasmania, 1881.
28. Verhandlungen der K. K. Zoologisch-Botanischen Gesellschaft in Wien, 32 Band, 1882.
29. Offenes Schreiben auf Herrn Baron Osten Sacken's "Critical Review" Meiner Arbeit über die Notacanthen, Von Prof. Dr. Friedrich Brauer.

30. Sitzungsberichte der K. böhmischen Gesellschaft der Wissenschaften in Prag, 1881.
31. Jahresbericht der K. böhmischen Gesellschaft der Wissenschaften in Prag, 17 Juni, 1881, do. 10 Juni, 1882.
32. Anales del Museo Nacional de México, Tomo 3, Entrega 3, México, 1883.
33. Journal of the Royal Geological Society of Ireland, Vol. 16, Part 2, 1881-82.
34. Proceedings of the Cambridge Philosophical Society, Vol. 4, Parts 2, 3, 4, 5, 1881-82.
35. Transactions of the Cambridge Philosophical Society, Vol. 13, Part 2, 1882.
36. Abhandlungen herausgegeben von naturwissenschaftlichen Verein zu Bremen, 8 Band, 1 Heft, Bremen, 1883.
37. *Mittheilungen der K. K. Geographischen Gesellschaft in Wien*, 1882, 25 Band.
38. Sitzungsberichte der Naturwissenschaftlichen Gesellschaft, "Isis" in Dresden.

Jahrgang, 1868, Nos. 1, 2, 3, 7, 8, 9, 10, 11, 12, 3 Nos.
" 1869, " 1—12, 4 Nos.
" 1870, " 4—12, 3 "
" 1871, " 1—12, 4 "
" 1872, " 1—12, 4 "
" 1873, " 1—12, 2 "
" 1874, " 1—12, 3 "
" 1875, " 1—12, 2 "
" 1876, " 1—12, 2 "
" 1877, " 1—12, 3 "
" 1878, " 1—12, 2 "

Mr. J. M. Clark, B. A., then read a paper entitled :—

SOME THOUGHTS ON THERMOTICS.

In the following paper it is proposed to consider in a few of their many aspects, the nature of heat, the laws of its propagation, its causes and its effects, noticing its correlation to the other forms of energy, and some more or less important applications of what we shall give some reasons for considering the true theory of heat to some of the problems of Chemistry, Geology and Meteorology. Heat being that in material bodies, which causes in us the sensation by virtue of which we call bodies hot or cold, hotter or colder, it is important at the outset to understand what that something in the physical world is. Prof. Tait, the eminent Natural Philosopher, in his valuable historical sketch of the Theories of Heat, says, that in the physical world, besides the inevitable Time and Space, there are but four elementary ideas, namely :—Matter, Force, Position and Motion. This statement seems open to very serious objection. Though time may from one point of view be regarded as one of the

conceptual elements of motion, and as such has been justly denominated the "great independent variable," yet to the physicist it cannot be regarded as by any means an elementary idea. This will be apparent if we remember the conventional measure of time universally employed. That measure shows that time is recognised, not as a primordial idea, but as a very complex conception involving motion, position and space.

Further, it seems utterly inconsistent with what is now known of the nature of force, to regard it as an elementary idea. If matter be really inert, the only rational use of the word force is to denote certain mechanical facts of motion. We may therefore for our present purposes regard space, matter, position and motion as the only elementary ideas in the physical world.

Heat consequently must be referred to these ideas or to combinations of them.

The experiments of Davy and Rumford demonstrated that heat cannot be matter, since they were able to extract an unlimited amount of heat from a limited quantity of matter, thus proving that the production of heat did not involve the consumption of matter. These experiments, together with an innumerable number of others of similar nature, show that the essential idea of heat lies in motion. But since to have motion matter must move, it is more correct to define Heat as a form of Energy than of Motion. From the fact that there is a mechanical equivalent of heat, it follows that the quantity of heat is proportional not to the quantity of motion, but to the quantity of energy. Thus Tyndall's brilliant work "Heat as a Mode of Motion," would have been more correctly and appropriately entitled, "Heat as a Form of Energy." Besides being more correct, this designation would have the important advantage of suggesting the remarkable connection of heat with light, magnetism, electricity, &c., by virtue of the Conservation of Energy, a principle, the discovery of which is perhaps the grandest reward of the scientific research of modern times.

Having then established that heat is a form of energy, it becomes necessary to consider the question—Are there two essentially different kinds of energy, kinetic and potential? If potential energy be defined (as it generally is) to be the energy of position, its existence is utterly inconsistent with the proposition that matter is inert, a proposition the truth of which lies at the foundation of Modern Physics.

Newton in one of his celebrated letters to Bentley, has justly said, "That one body may act upon another at a distance, through a vacuum without the mediation of anything else by and through which their action may be conveyed from one to another, is so great an absurdity, that no man, who has in philosophical matters, a competent faculty of thinking, can ever fall into it." From this it inevitably follows, that no body, or system of bodies can possess energy merely by virtue of its position, in other words by virtue of the distances of its parts from all other bodies. In this sense, therefore, potential energy involves a contradiction in terms.

But if we regard potential energy as a convenient name for those kinds of energy whose nature is not yet understood, the term is convenient and admissible, though liable to create considerable confusion. There are not therefore two distinct kinds of energy—energy of motion, and energy of position. The distinction can, in the nature of things, have no possible fundamental difference for its basis. But energy may be conveniently divided into two classes, namely, energy whose nature we in some measure understand—called kinetic—and energy—known on the other hand as potential—of whose nature we know comparatively little, but which we regard as dependent on position, not that this dependence is an ultimate physical fact, but because it is a secondary or conventional mark, which, in the absence of more definite knowledge, it is convenient to adopt.

Heat then, being beyond doubt, a form of energy, it is important to determine in what forms of matter the heat energy resides, whether for instance, in heated bodies, the vibrations, by virtue of which the bodies are said to be hot are vibrations of the atoms or of the molecules.

Notwithstanding the high authority of Tyndall to the contrary, there is good reason to suppose that heat properly so called, consists exclusively in molecular motion. To make out the probability of this apparently bold assertion, it is necessary to investigate the real nature of what is most erroneously called radiant heat, but which possesses no more of the characteristic qualities of heat than the motion of a hammer about to strike an anvil. Tyndall himself has conclusively proved, not only that radiant heat is not matter as is confusingly suggested by the origin of the phrase, but what is more to the point, that it is nothing more or nothing less than a wave motion of the luminiferous ether, which prevades not only all interstellar, but also intermolecular and interatomic space.

By the way, we may notice that the term luminiferous ether which is derived from its connection with the theory of light, and which does not at all suggest the varied functions which this mysterious medium is now supposed to fulfil is fast losing its appropriateness. In view of the recent advances in Molecular Science, energipherous would seem a much fitter term.

Though this name is suggested by the nature of radiant heat the coining of a new word is further justified by the views as to the nature of electricity, magnetism, &c., advanced by Maxwell, and now held by the leading investigators in that important field of knowledge.

Further, analysing light by the spectroscope, and remembering that on the undulatory theory of light, which is one of the most completely verified hypotheses of modern science, refrangibility is proportional to the wave-length, we can be certain that in any given section of the spectral band, whether in the doubtfully so-called thermal, luminous or actinic portions, we have vibrations of a determinate wave-length.

Now it is found by means of the thermopile that the luminous portion of the spectral band has a heating effect, proving that luminous rays are also thermal rays, or that the identical rays, which falling on the optic nerve would excite the sensation of light, when allowed to strike the face of the thermopile produce the effects of heat.

This important identity is rendered probable by the fact that certain substances absorb light, the only explanation of the disappearance being that the substances are more or less heated. Leslie has shown experimentally that this heating does in fact take place.

Combining this conclusion with the property known as the transmutation of rays, a property discovered by Stokes, who succeeded in so diminishing the wave-lengths of the ultra-violet rays of the spectrum (by the interposition of thin plates of certain substances) as to render them visible, it follows that the fact of heat-producing chemical decomposition which can only be effected by an acceleration in the motions of the constituent atoms of the molecules, or in other words by interatomic forces, does not at all prove that heat consists in atomic as distinguished from molecular vibrations.

Even should Lockyer's hypothesis that in the enormously heated atmosphere of the sun the supposed elementary bodies are dis-

sociated, and their existence, as such, rendered impossible be proved, the same reasoning goes to show that the necessity of supposing the seat of the heat vibrations to lie in the elementary constituents of the molecules would not follow.

Tyndall in one of his contributions to Molecular Physics argues that since the power of absorption of a vapor depends on that of the liquid from which it has been obtained, or since the state of aggregation does not alter the relative power of absorption of bodies, the seat of absorption must lie in the atoms—not in the molecules—the relative positions of the molecules being altered, and consequently the conditions of molecular motion. To this it may be replied that the change in the intermolecular relations involved in a change in the state of aggregation of a body does not necessitate any alteration in the periods of the molecular vibrations but may merely lengthen or shorten their amplitudes.

On the other hand were the atoms the seat of the heat vibrations, such undoubted facts as that water has such profoundly different physical properties from both hydrogen and oxygen, that ozone has many times the absorbing power of oxygen, and that ammonia has about 5000 times the absorbing power of either of its constituents, hydrogen or nitrogen, would be utterly incapable of explanation. On the whole these considerations, combined with the general law that heat for the most part produces physical and not chemical effects, though molecular motion may undoubtedly be transformed into atomic motion subject to the law of the conservation of energy, seem to point irresistibly to the conclusion that heat is not only a form of energy but more particularly that it consists in molecular motions. The relation of heat to light is shown clearly by the analysis of light by means of a prism, and lies in the fact that all the undulations of the energipherous medium, if transformed into the molecular motion of bodies, or if allowed to excite the tactile nerves manifest themselves in the form of heat, while only a limited portion when allowed to strike the eye excites the optic nerve and produces the sensation of sight. In a manner which we now propose briefly to describe similar, more or less intimate, connexions have been established between heat and the other forces of nature, so that heat, light, electricity, magnetism, sound, chemical affinity, potential and mechanical energy are now generally regarded as but different forms of an unchangeable amount of indestructible energy.

There can be now no doubt that the theoretical foundation for the modern doctrine of the conservation of energy, of which the equivalence of heat and work is a particular case, was distinctly and substantially laid by the genius of Newton in his wonderful scholium to his Third Law of Motion.

In this scholium and in the commentary on it Newton not only enunciates the law of conservation of energy, so far as the state of experimental science in his day would permit, but also clearly anticipated the so-called modern principle of Vis Viva and D'Alembert's principle. No further advance of any moment seems to have been made till about 100 years later Davy and Rumford proved experimentallv the immateriality of heat. To Rumford is mainly due the credit of having rescued the question of the nature of heat from the domain of metaphysics, and of having devised several ingenious experiments, by means of which he arrived at a remarkably approximate value of the mechanical equivalent of heat. The next important names in connection with the history of the theory of heat are those of Fourier and Carnot. The calculations and conclusions of these profound mathematicians were expressed, it is true, in terms which to a certain extent involved the now exploded corpuscular theories of light and heat, but their reasoning and results were to such an extent independent of any particular theory that the elements involving the truth of these untenable hypotheses are capable of being almost entirely eliminated, leaving results which have proved of the greatest use in the development of the true theory of energy. Perhaps the most important of the many valuable contributions of Clausius to the theory of heat was his adaptation of the theorem of Carnot, so as to make it consistent with the principle of the equivalence of heat and work.

To Joule, the great English physicist, is undoubtedly due, as has been conclusively shown by Prof. Tait, the credit of having placed the grand law of the conservation of energy, of which the first main principle of the mechanical theory of heat is but a particular case, on a sure experimental foundation. By means of some of the most ingenious and refined experiments of modern times, Joule determined that 772 foot-pounds of work, if converted into heat, would raise 1 pound of water 1°.F., or that to produce a quantity of heat sufficient to raise 1 kilogramme of water through 1° C. work must be consumed to the extent of 424 kilogrammetres, and thus placed

the truth of the dynamical theory of heat beyond all manner of doubt. His results have been extended by Helmholtz, Mayer, Clausius, and Thomson, till the law of conservation has been shown to govern all natural forces.

Thomson demonstrated that Faraday's discovery of the rotation of the plane of polarization of a polarized ray of light, produced by media under the influence of a powerful magnet, involved the dependence of magnetism on motion.

The extension of the principles of the conservation and transformation of energy to physiological phenomena has been largely due to Helmholz and Carpenter.

There can be no doubt that Maxwell's electro-magnetic theory of light is destined to play no unimportant part in the development of the true theory of energy. From data supplied by Weber Maxwell, found that electro-magnetic disturbances were propagated with the same velocity as light. The explanation of this he held to be that electricity like light was due to the undulatory vibrations of the medium, which is beyond question necessary for the propagation of light. Should this hypothesis be found to be a valid one, a very clear insight will be obtained into the real connexion between electricity, light, and radiant heat.

From what has preceded, it will be seen that the mysterious, all-pervading ether plays an increasingly important part in the prevailing physical theories. To such an extent is this the case that Tyndall has justly remarked that its relations to the matter of the universe must mainly occupy the investigations of future scientists. In order to form a more definite idea of the properties of this highly attenuated substance, which is yet so elastic and incompressible, that Stallo has characterised it as an adamantine solid, it is now proposed to attempt a calculation of its probable density. To accomplish this object, it is necessary to know the amount of radiant energy emitted by the sun. This determined by careful observations with the pyrheliometer, and expressed by means of Joule's mechanical equivalent of heat, amounts to 5,500,000 foot-pounds per second from every square foot of the sun's surface.

Now, the velocity of light is 186,000 miles per second. Therefore the radiant energy sent forth by the sun during any given second of time will at the end of that second be contained between two spheres, the smaller 433,000 miles, or the semi-diameter of the sun for radius,

and the larger 619,000, or 433,000 + 186,000 miles. The volume of this space is—

$$\frac{4\pi}{3}(5280)^3(10)^9\left\{(619)^3-(433)^3\right\}\text{ cub. ft.}$$

Also, the surface of the sun is $4\pi(433)^2(10)^6(5280)^2$ sq. ft. Therefore 1 cubic foot of ether is agitated by—

$$\frac{4\pi(433)^2(10)^6(5280)^2\times 5500000}{\frac{4\pi}{3}(5280)^3(10)^9\left\{(619)^3-(433)^3\right\}}$$

$$=\frac{5500000}{5280\times 279000}\text{ foot-pounds of energy.}$$

Let m represent the mass of each ether-particle, or the average mass if the ether-particles are not uniform, and n the number of such particles in a cubic foot, so that $nm = M$ will be the number of pounds of ether in a cubic foot.

Using the ordinary equation of the harmonic curve—

$$y = a\sin\left(\frac{2\pi x}{\lambda}+\alpha\right)$$

it will be seen by differentiating twice that the maximum velocity of any particle owing to any single wave is $\frac{2\pi a}{\lambda}V$, where a is the amplitude, λ the wave length and V the velocity of propagation. Hence the energy of a particle whose mass is m, under such circumstances is—

$$\frac{m}{g}\,\frac{2\pi^2a^2}{\lambda^2}\,V^2\text{ foot-pounds.}$$

Therefore the energy of a cubic foot of ether is—

$$\Sigma\frac{m}{g}\,\frac{2\pi^2a^2V^2}{\lambda^2}=\frac{M}{g}\,\frac{2\pi^2a^2V^2}{\lambda^2}$$

Equating these two expressions for the same quantity of energy we get as the mass of a cubic of ether

$$M=\frac{g\lambda^2}{2\pi^2a^2}\,\frac{5500000}{(186000)^2(279000)(5{,}280)^3}\text{ lbs.}$$

It will be seen that the only assumption involved in this calculation is that the average velocity of the ether particles may be taken to be equal to the maximum velocity in consequence of a single wave motion.

In order to arrive at a numerical result we have to find the value of $\frac{\lambda}{a}$, and of these two quantities only one λ has been experimentally determined.

However, remembering that on the undulatory theory of light a diminishes with the distance from the centre of radiation we are certainly safe in supposing that even in the region of space we are considering a cannot possibly be greater than 200λ.

It is scarcely possible that the velocity of the ether-particles can exceed 233,626,000 miles per 1″, the stupendous rate necessitated by this supposition. Substituting for $\frac{\lambda}{a}$ $\frac{1}{200}$ and multiplying the result by $(5280)^3$ we conclude that the mass of a cubic mile of ether is not less than $\frac{1}{4}\left(\frac{1}{10}\right)^{13}$ of a pound. Now a cubic mile of air (at 0° 760mm) contains $(10)^{10}$ lbs. Therefore air is not more than $4(10)^{23}$ times denser than the ether.

Using this value for the density, a sphere whose radius is the same as that of Neptune's orbit, or 276,000,000 would contain $2(10)^{12}$ lbs. of ether or a sphere whose radius is 95,000,000 miles, the distance of the earth from the sun, would contain 4,400,000 tons.

If we suppose, as reasoning from acoustical analogies there is considerable reason for doing, that a instead of being 200 times greater than λ is 5 times less, a cubic mile of ether would contain $\frac{1}{4}\left(\frac{1}{10}\right)^7$ lbs., or a sphere of the same dimensions as the earth would contain about 6,500 lbs.

After having made the above calculations, and in the course of a vain search for further data as to the value of $\frac{\lambda}{a}$ we found that some years ago Sir W. Thomson had attempted a similar undertaking, and by means of a somewhat different method of investigation, had arrived at the conclusion that the probable density of the ether was 25 times less than that given above.

Considering the uncertainty of the assumption as to the ratio between the amplitude and wave-length of the ethereal vibrations, the coincidence is satisfactorily close.

Although, as has been pointed out, the quantity of energy in the

universe is invariable and can neither be increased or diminished, yet by virtue of laws of which we have a particular case in Clausius' "Second Main Principle of the Mechanical Theory of Heat," the amount of what may be termed available energy is being constantly exhausted.

The truth of this, together with many very important consequences which follow from it, was first pointed out by Sir W. Thomson in a remarkably able paper on a "Universal Tendency in Nature to the Dissipation of Mechanical Energy." It is simply another method of saying that no known natural processes are perfectly reversible.

A few moments reflection will suffice to show that the main sources of energy available for man are (1) Food; (2) Fuel; (3) Water Power; (4) Wind. Of these food and fuel are of the same nature, food being utilized by means of animal machines, such as men, horses, &c., while fuel is converted into mechanical motion by means of engines of various kinds. The mechanical energy which is thus produced by means of food and fuel is evidently, for the most part, derived from the heat and light radiated from the sun. Water power and wind even more obviously obtain their energy from the same source. Solar radiation is therefore the grand source whence nearly all the energy available for man is derived.

Various theories have been advanced to account for the enormous amount of energy in the form of heat and light annually sent forth by the sun, and of which the earth intercepts a very small portion. It was, for instance, supposed by some that the sun's heat was produced by the combustion of its materials. A very few facts will show that this hypothesis is utterly untenable. The mass of the sun, estimated from the most reliable determinations of the solar parallax, has been found to be about $4(10)^{30}$ lbs. The consumption of a pound of coal is known to produce an amount of heat equivalent to 9,200,000 foot-pounds.

Combining these, we see that if the materials of the sun were supposed to be capable of producing by their combustion as much heat as equal masses of coal, an assumption eminently favorable to the hypothesis in question, the total mass of the sun would be consumed in producing a quantity of heat whose mechanical equivalent is $368(10)^{35}$ foot-pounds. In estimating the probable density of the ether, it was found that the quantity of energy radiated from the

sun was $4\pi(433)^2\,(10)^6\,(5280)^2$ 5,500,000 foot-pounds per second, or $(10)^{31}$ foot-pounds per annum. It therefore follows that if the theory of the origin of solar heat under examination were the true one, the energy of the sun would be completely exhausted in 3,680 years, while we know that the quantity of heat radiated from the sun has been practically as great as at present for millions of years. The theory of combustion or chemical combination, therefore, falls to the ground, and it is now generally supposed that the perennial fountain whence flow the vast energies of the solar system, is the potential energy of gravitation which is converted into kinetic energy by its mass moving towards the centre of inertia of the solar system, and thence into heat by a mechanism indicated by the physical constitution of the fiery ruler of the day.

The following investigation will show that this now generally accepted hypothesis predicates a cause known to be a *vera causa* amply capable of producing the results it is supposed to explain, and that therefore it is not inconsistent with the axiom that the cause must be equal to the effect.

Let ρ represent the density at distance r from the centre of a spherical mass, supposed equally dense at equal distances from the centre. The elemental mass, therefore, between the spherical surfaces whose radii are r and $r + dr$, is $\rho\, 4\pi r\, dr$.

Taking proper units of force, &c, and remembering the theorem that the attraction of a spherical shell on an internal particle vanishes, it follows that the force acting on this elemental mass is measured by the quantity—

$$\frac{4\pi\rho r\, dr \int_0^r 4\pi\rho r^2\, dr.}{r^2}$$

assuming of course the Newtonian law of gravitation. The work done by this elemental mass moving through an infinitesimal dc, will consequently be—

$$\frac{4\pi\rho r\, dr \int_0^r 4\pi\rho r\, dr\, dc.}{r^2}$$

Integrating with respect to dr we get as the total work done—

$$\int \left\{ 4\pi\rho\, dr. \int_0^r 4\pi\rho r^2\, dr. \right\} dr.$$

a formula which will be found to be of considerable use in solving certain important classes of problems.

Supposing ρ to be constantly uniform if the radius of the sphere be originally a and become $a - da$, dc will evidently be $\frac{r}{a}\,da$, and the total amount of work done on account of the contraction, will consequently be $\frac{3}{5}\,M^2\frac{da}{a}$, where $M = \frac{4\pi}{3}\,\rho\,a^3$, the mass of the sphere.

Integrating this expression between the limits a and b we get as the amount of work done by a spherical mass M of radius a (supposed uniform) contracting to a uniform sphere of radius b, $\frac{3}{5}\,M^2\left(\frac{1}{b} - \frac{1}{a}\right)$.

Applying these formulæ to the case of the sun whose radius is 433,200 miles and whose mass is $4\,(10)^{30}$ lbs., the amount of work done, or in other words, the quantity of heat generated, by a contraction of 1 foot in the radius of the sun (supposed uniform) will be found to be represented by—

$$\frac{3}{5}\,\frac{16\,(10)^{60}}{(433200)^2\,(5280)^2}$$

The unit of force used here obviously is the attraction of unit mass on unit mass at unit distance; so that the attraction of the earth on unit mass at its surface would be represented by—

$$\frac{4}{33}\,(10)^{26}\,\frac{1}{(4000)^2\,(5280)^2}$$

multiplied by the mass of the earth $= \frac{4}{33}\,10)^{60}$ of these units.

Now this force will cause 1 lb. to move through $\frac{g}{2} = 16{\cdot}1$ ft. per second.

Therefore a contraction of 1 foot in the sun's radius will generate a quantity of heat equivalent to—

$$\frac{3}{5}\,\frac{16\,(10)^{60} \times 33 \times (4000)^2 \times (5280)^2 \times 16{\cdot}1}{(433200)^2 \times 4 \times (10)^{26}}$$

$= (10)^{33}$ foot-pounds.

If account were taken of the fact that the sun must become denser as its centre is approached, this quantity would be considerably larger.

Accordingly a yearly contraction of 10 feet in the sun's radius would be amply sufficient to sustain its heat at the present rate of radiation.

A decrease in the diameter of the sun of less than 20 miles would keep up the supply for over 5000 years. The most refined instruments would not be sufficiently precise to detect so small a variation.

If on the same hypothesis, the sun's radius were to become one-half what it now is, or the density of the sun eight times its present value, which would make its density about the same as that of lead, instead of—

$$\frac{3}{5} M^2 \frac{1}{(433200)^2 (5280)^2}$$

for a contraction of 1 foot, we should have

$$\frac{3}{5} M^2 \left(\frac{1}{\frac{1}{2}(433200)(5280)} - \frac{1}{(433200)5280} \right)$$

i.e., about 433200 × 5280 times as much heat would be generated.

This would be sufficient to sustain the present rate of radiation for 22,000,000 years. Similarly if the mass of the sun were equally diffused throughout a sphere having a radius of 276,000,000 miles, which is the distance of Neptune from the sun, and were to contract till it became uniformly as dense as lead, heat enough would be produced to meet the present demand for 44,000,000 years. Further, if the solar mass had the same specific heat as water, and were raised to a temperature of 28,000°, it would contain a store of heat 2,000,000 times as great as the present yearly expenditure.

These figures, curious and instructive in themselves, derive considerable importance from their bearing on the problems of geological time, when taken in connection with the vast æons considered necessary by most geologists for the formation of the different strata of rocks, and with the still vaster ages claimed by biologists for the evolution of the existing and extinct forms of animal life.

The palæontological evidence for the high development and wide dispersal of organisms, at least in later palæozoic times, is complete; and to the existence of a flora and a fauna, such as that indicated even in the Cambrian formations, a mild climate is absolutely essential. Now though climate is profoundly affected by the presence of mountains and large bodies of water, and even more by winds and ocean currents, and by the quantities of the variable elements in the atmosphere, yet to maintain a mild climate the heat-giving power of the sun must have been materially as great as at present.

The heat generated by the sun in assuming its present density and conformation can not be supposed to be greater than that produced by contraction from the limits of the solar system to a homogeneous sphere of one-half its present radius.

This would make 44,000,000 years, the limiting age which can be assigned to the Cambrian formations.

We shall conclude by applying the principle that the absorptive power of a vapour is determined by that of the liquid from which it is derived, to explain the empirical law (enunciated by Mr. McGee) that any increase in annual or diurnal range is accompanied by a diminution of mean temperature. The aqueous vapour of the atmosphere, being derived from water, which has a comparatively high absorptive power, must also possess considerable power of absorption, and Tyndall has conclusively shown experimentally that such is the case. Also, the power of radiation is strictly proportional to the power of absorption, as is known both from theory and experiment, so that the aqueous vapour of the atmosphere is both a good absorbent and radiant.

Now, when the temperature is raised, not only will the aqueous vapour of the atmosphere be heated, but a larger amount of it will be formed, and as gases expand when heated, this vapour will tend to rise to the higher regions of the atmosphere, and radiate its heat into space. On the other hand, in a comparatively cold season the relatively cooled vapour tends to descend, the heated vapour from the surface of the earth ascends, and imparts its heat to cold space.

Also the amount of heat received from the sun may for our present purpose be considered as invariable from year to year, so that the two actions above mentioned show that the radiant absorbent and expansive powers of aqueous vapour combine to lessen the relative amount of heat retained by the earth, during both exceptionally high and exceptionally low temperatures, *i. e.*, during a period of large thermometric range, and consequently to diminish the mean temperature.

There may be and probably are other con-causes of this effect, but the one we have assigned is certainly a real and efficient factor in producing the apparently anomalous result in question.

In the discussion which followed the reading of Mr. Clark's paper, Mr. Geo. E. Shaw, Mr. J. G. Mowat, Dr. Jos. Workman, and Mr. J. M. Buchan took part.

SEVENTH ORDINARY MEETING.

The Seventh Ordinary Meeting of 1883-84 was held on Saturday, December 15th, the President in the chair.

The minutes of last meeting were read and confirmed.

The following gentlemen were admitted members:

Mr. R. W. Phipps, Mr. William Leslie Beale, Mr. Arthur J. Graham, John J. Cassidy, M. D.

List of donations and exchanges received since last meeting:—

1. Journal of the Franklin Institute for October, 1883.
2. Tillaeg til Aarboger for Norske.
   Oldkyndighed og Historiae, Aargang, 1879.
3. " " " 1880.
   Kjobenhavn, 1880-81.
4. Mémoires de la Société des Antiquaires du Nord, Nouvelle Série, 1881.
5. Bulletin of the Museum of Comparative Zoology at Harvard College, Vol. 11, Nos. 3 and 4.
6. Science, Vol. 2, No. 44, December 7th, 1883.
7. Appleton's Literary Bulletin, December, 1883.
8. Transactions of the Manitoba Historical and Scientific Society, Nos. 5 and 6.
   " " " " Nos. 1 and 2, 1883-4.
9. Proceedings of the Asiatic Society of Bengal, Nos. 1 to 8, January to September, 1883.
10. Journal of the Asiatic Society of Bengal, Vol. 52, Part 2, No. 1, 1883.
11. Scientific Proceedings of the Ohio Mechanics' Institute, Vol. 2, No. 3, September, 1883.
12. Waifs in Verse, by G. W. Wicksteed, Q. C., Law Clerk House of Commons of Canada, presented by the author.
13. Transactions of the Manchester Geological Society, Vol 17, Part 10, Sessions 1883-84.

Mr. T. B. Browning, M. A., then read a paper entitled, "England's Oldest Colony."

Mr. Browning opened his paper by commenting upon the indifference with which the Provinces of British North America treat each other, and proceeded to discuss the rights which the French have in that part of Newfoundland called the French Shore under the treaties of Utrecht, Paris, and subsequent arrangements. He also alluded to the Banks fishery, and stated that the French employ about 700 ships in this and the shore fishery, about 28,000 seamen, and make

an annual catch of a million quintals of codfish. The rights of the French seemed to him to be greatly detrimental to the interests of Newfoundland, made the richest part of the island practically a sealed book, and were a continual source of trouble to both England and France. He further referred to the rights which the Americans exercise under the Treaty of Washington, and showed that stringent regulations were become needful, in the interest of all, to prevent wanton destruction and depletion of the Newfoundland fisheries, upon which so great a part of the world depended for a great part of their food supply.

He next described the geographical position and geological formation of the island. its copper, coal, iron deposits, and made particular reference to currents along shore, which he stated to be the cause of the many shipwrecks which happen near Cape Race and St. Shotts. Having called attention to the city and harbour of St. Johns, the capital of the island and its principal attractions, he proceeded to discuss the foreign trade of Newfoundland, which, he said, is being drawn to the chief town more and more year by year, and which he placed at $16,000,000 annually. The land question next came under review in two branches; first, as regards the waterside premises of St. Johns which are built on leased lands, the leases of which expire in a year or two, and concerning which legislative action is contemplated in the coming session. Newfoundland has developed with her landlords a crisis similar to that with which Ontario had to deal in her clergy reserves, Quebec in her seignorial tenures, Prince Edward's Island in her proprietory rights.

Touching upon the larger question of land tenure Mr. Browning referred to the decrees of the Star Chamber 1630, to statute 10 and 11 Wm. III., and 15 Geo. III., ch. 31, as establishing communism in land. No man could own any acre of the soil, no reserves were given to the Protestant or any other church, and no power was granted to the governors to pass a title to land. This communism continued until 1820, and made the country a fishing preserve for the west country merchants. It enriched England and developed her maritime power, but impoverished the soil of Newfoundland. A geographical survey of the country into counties, townships, sections and lots is still to be made, and is needed for agricultural and lumbering purposes.

He then referred to certain manners and customs of the people, particularly to the gambols of Christmas-tide, which, long since dead in England, flourished in Newfoundland until about twenty years ago. He gave statistics showing the progress of total abstinence, and described the chief agencies in the movement as well as the lineage and religion of the inhabitants of the island. It seems that the first colony permanently settled in Newfoundland was that of John Guy, who acted as manager for a company in which Lord Bacon was a shareholder. Colonies were also formed by Lord Baltimore in 1623, and several by the French and Portuguese.

The main industries were described as the summer and spring fisheries; the first of cod, salmon and herring, the second of seals. The fish caught was valued at from ten to twelve million dollars, the number of seals reckoned at a yearly average of 600,000. The condition of the fishermen, which had been almost hopeless from the crushing weight upon them of the supply system, was improving. Education was doing something for them, facilities of communication more. Their great need was a home market, at least a market nearer than Brazil, Spain or Italy. Formerly Newfoundland's surplus wealth was drawn to the West of England, the shores of the Mersey and Clyde, but is now adorning her own capital and spreading a spirit of enterprise among her people. They look to Canada and the West rather than to Britain and the East. The question of Confederation, he said, is with Newfoundland one of terms, and may be expected to be answered in the affirmative in the near future.

In the discussion which followed Mr. J. M. Buchan, Mr. Fred. Phillips, Mr. James Bain, jun., Mr. Geo. E. Shaw, Mr. John Notman, and Mr. B. B. Hughes took part.

EIGHTH ORDINARY MEETING.

The Eighth Ordinary Meeting of the Session 1883-'84 was held on Saturday, December 22nd, 1883, the President in the chair.

The minutes of last meeting were read and confirmed.

The following gentlemen were elected members of the Institute :—

H. H. Langton, B.A., Charles Miles, C.E., S. George Curry, Architect.

The following exchanges were announced :

1. Annual Report of the Museum of Comparative Zoology at Harvard College for 1882-'83.
2. Science, Vol. 2, No. 45, December 14, 1883.
3. Monthly Weather Review for November, 1883.
4. Report of the Superintendent of the United States Coast and Geodetic Survey for the year ending June, 1881.

Mr. Alan Macdougall, C.E., F.R.S.E., read a paper entitled :—

CANADIAN CATTLE TRADE AND ABATTOIRS.

The dependence of Britain on foreign or extraneous sources for much of its food supplies has led to the formation of numerous industries all over the world, and especially on the North American Continent. For its bread-stuffs it may be said to be wholly dependent on the United States, as the quantities sent over from there entirely dwarf the receipts from European countries. Out of the amount exported to Europe, Britain receives 75 per cent. of the wheat, and 90 per cent. of the flour and corn. The wheat crop in 1880 a failure in most of the European countries was a surprisingly abundant one in the States, and it is due to this that many of these countries were saved from starvation.

As the intercourse between Britain and her colonies has increased closer trade relations have been established, and with none have these relations grown to greater bulk than with our Dominion. Our export of bread-stuffs are assuming gratifying proportions, year by year they increase, and year by year the importance of our magnificent waterways grow in like magnitude. Our exports of bread-stuffs

have increased to such proportions as to cause the St. Lawrence to be considered a formidable rival to the ports of the Eastern States. This route has opened up the way for the export of other agricultural products, among which is the important trade in cattle which has sprung up between this Province and Britain. The fattening of cattle for the British market has been carried on in our midst in such a quiet unobtrusive manner, few people are aware of the large volume of trade done in this line, or of its financial results to our Province and the Dominion.

From the last return of the Bureau of Industries for the Provinces of Ontario and Quebec, it is learned that our Province exported in the years 1871-'81 :—

Eggs, to the value of	....	$4,114,040
Butter "	.....	4,240,564
Cheese "	.....	9,277,459

If the totals given for the two Provinces be taken the exports of

Eggs were of the value of	....	$5,283,557
Butter "	.....	29,625,762
Cheese "	.....	37,243,351

It is not necessary for the present purpose to detail the amounts which went to Britain, the States and elsewhere.

The export of cattle and sheep has increased very much within the last six years, particularly to Europe. The figures to Europe, are :

Year.	Cattle.		Sheep.
1877.	6,940	....	9,509
1878.....	18,655	.....	41,225
1879.....	25,009	... .	80,332
1880..... .	50,905	. .....	81,843
1881.....	45,535	.....	62,404
1882	35,738	.....	75,905

The Shipments to Great Britain, were in

	1880.		1881.		1882.	
	Cattle.	Sheep.	Cattle.	Sheep.	Cattle.	Sheep.
Montreal.. ...	35,416	67,943	32,722	39,218	28,183	65,183
Quebec.....	9,894	11,208	9,212	21,809		
Halifax.....	5,595	2,692	3,601	1,374		

The values of horned cattle and sheep exported in 1882, were for

HORNED CATTLE.

Province.	To Britain.	To United States.	To All Countries.
Ontario	$ 72,972	$ 374,858	$ 449,590
Quebec	2,316,604	45,517	2,363,296
Dominon	2,706,051	423,807	3,256,330
SHEEP.			
Ontario	$ 20,976	.....	$ 491,640
Quebec	446,755	.....	606,050
Dominion	510,152	.....	1,228,957

Beef to the value of $49,798 was exported from the Dominion in 1882, of which $25,095 went to Britain.

The falling-off in the numbers of cattle in 1882 is due to the increased number exported to the States, and also to the large shipments made in the prior three years, when all the marketable cattle were sent to Britain, and thousands of beasts left this Province which ought to have been kept here.

The total returns of cattle exports in 1882 are in excess of those of other years.

The improvement in quality is becoming more marked every year by the use of Shorthorn, Hereford and Angus bulls, which must in a few years greatly increase the value of Canadian cattle. Mr. Dyke, the Dominion Agent in Liverpool writes, that our cattle can compare favourably in points of breeding and quality with those bred in the best districts of Great Britain, and that this is specially noticeable in sheep.*

In all agricultural statistics relating to the Province of Ontario, the Province of Quebec has to be joined as the ports of shipment. Montreal and Quebec are in the latter, and exports are given from that Province far in excess of its legitimate trade, and belittling to our Province. The question is taken up in the last report of the Bureau of Industries, and ably treated by the energetic head of the department. He places the proportion for Ontario at 75 per cent. of the total exports. Prior to 1876 fully 80 per cent. of our exports went to the States, since that year the returns show a considerable increase in the shipments to Great Britain.

The total value of agricultural products sent to Great Britain from the two Provinces during the years 1871-'81 amount to the

* Sessional Papers Dom. Can. 1883, App. XIV., p. 199, *et seq.*

magnificent sum of $175,042,730, and to all countries to $325,-919,720.

In the dead meat trade the largest returns are made from the Province of Nova Scotia; this may be due to shipments of dressed beef and mutton being made in winter when carcases are frozen by natural means, and are in a condition to bear a long railway journey and several handlings with impunity, whilst the shipment of live animals is confined to the warmer portions of the year when navigation is open.

The Dominion does not appear to have entered so largely into this branch as the States, from which the supply has decreased considerably in the last two or three years. It is affirmed by some authorities that there was not a sufficiently large margin to encourage a continuance, when Australian meat was being imported so sucessfully; whilst others declare that home consumption has increased, chiefly in the west and north-west through the large immigration of the last two years, and consequently the demand was equalling the supply.

It may not be out of place to mention that in some British cities, Canadian dairy produce is much belittled, whatever is good in butter or cheese is called "American," and what is bad American is too often called "Canadian!" One city can be named in which a depot for Canadian produce was opened, and where? in one of the poorest and lowest parts of the city! "American" beef, mutton, butter and cheese can be obtained at numerous places, while "Canadian" is unknown.

The present cattle trade was commenced in 1876, and had its inception in this city. It was really an experiment. No one knew any thing of it. Shippers, ship-owners and harbor authorities were all in ignorance of the requirements of the trade. The first steamer chartered could only carry 150 head of cattle, and now the same ship carries 350. At the ports of debarkation no preparations had been made. It was difficult for the Liverpool harbour authorities to believe cattle could be brought across the ocean in large numbers free from infection or disease, when in spite of every care and attention outbreaks of pleuro-pneumonia and other diseases could not be checked in Britain.

In the earlier days of the trade heavy losses were incurred. The

experience of to-day has indeed been dearly bought. Still it is highly satisfactory to learn that the losses are merely trifling.

	Cattle.	Lost.		Sheep.	Lost	
		No.	P. C.		No.	P. C.
The Dominion S.S. Line carried in 1882	6,057	41	0·67	20,241	522	2·57
Do., 1883	7,963	54	0·70	21,553	989	4·60

	Cattle.	Sheep.
Montreal exported in 1876	2,830	2,686
" " 1883	50,365	102,835

It was not until the third season that the Liverpool authorities became alive to the importance of this trade. When they did so, with commendable promptitude they erected those handsome and commodious lairages, pens, slaughter-houses, &c., which now expedite the trade and allow of a ship-load of animals being slaughtered within 24 hours of debarkation.

In addition to all the vexations, losses, &c., incurred in the earlier days from the want of sufficient knowledge of the requirements of the trade, as well as having the opposition of the British farmer and cattle dealers to overcome, the provisions of the Contagious Diseases (animals) Acts had to be complied with. The depredations caused in Britain during the past 20 years by numerous diseases are unfortunately only too well known; in spite of the most stringent measures, the Government has failed to entirely stamp out these diseases, and valuable herds and animals are still daily lost by their ravages.

Recent statistics shew that there are in the United Kingdom 32,237,958 sheep and lambs, the loss due to diseases brought on by the recent wet seasons is estimated at 2,889,000, or nine per cent. The Canadian farmer may complain about the severity of the winter, but he has nothing to fear compared to his British brother.*

To guard against any spread of these diseases strict quarantine laws have been established applicable to all foreign countries, which necessitated the cattle being slaughtered within 24 hours of debarkation, and at the port of arrival. It must be a subject of much congratulation and pride to us all, that the Dominion of Canada is the only country which has never come under the clauses of the Act, or been

* Dyke—loc. cit.

"scheduled." Fortunate it is for us we are free from restrictions, and long may we continue to be so. It is only those persons who have had experience of the workings of that measure who can understand what a bane it is to a country, or how it interferes in its trade. Exhibitors of live stock have frequently failed to come up to their usual standard, and orders to slaughter cattle at home markets have interfered with their prices. Under the Act, every time an animal is put into a cattle car, the car has to be disinfected before it is allowed to be used again; the floor has to be washed out, all offal removed, and the car has to receive a coating of lime white-wash; every pen used for loading, unloading, or holding cattle, be the time ever so short, has to be white-washed. To move animals by road, permission has to be obtained from the Local Authorities, who have plenty of inspectors always on the look out for a breach of the law.

The best illustration of the care devoted to cattle in our province, is afforded in the large byres in this city for fattening cattle for the English market. There are at present 4,000 cattle distributed over six large feeding stables, or byres, each of which contains about 600 head; and there are also a large number of pigs. Each byre is one open space, there are no partitions, the cattle stand close together from 40 to 50 in a row; between each row are 2 troughs separated by a footway for the attendant to pass along, the troughs are sufficiently far apart to prevent the animals from horning each other. At the rear a similar arrangement receives the manure, urine, etc., these troughs are about 3 ft. wide, 3 ins. deep at the top, and 9 ins. at the outfall. A simply arranged system of sluices lets the distillery wash flow into the troughs. Overhead is a large loft for hay, having openings directly over each line of troughs, through these the hay is dropped down directly to the animals. The "wash" is supplied directly from the distillery which is about 1,100 yards distant; it comes boiling hot, and is received in large vats holding 30,000 gallons each; it does not cool very much and is fed to the animals hot; each animal receives 20 gallons on the average, per diem. The stalls are carefully scraped out three times a day, all manure and urine is drawn into the troughs outside the buildings, from which it is run off twice a day. The atmosphere of the byres is wonderfully sweet.

After the manure has been drawn into the outer troughs it is allowed to settle, and all solid matter is pitchforked on to a planked roadway, the liquid is further screened by being passed through

gratings one inch wide, after which it is carried down into the lake at Ashbridge's Bay. The byres and outfall troughs are all well flushed with fresh water every day. The solid manure is carted away, daily, by market gardeners and farmers in the neighbourhood of this city; they get it free, each contractor receives the manure of two rows, and there has never been any trouble nor has the manure been allowed to lie for more than twenty-four hours.

The animals come in during the month of October and go out in June, during that time they make from 1,500 to 1,800 lbs. in weight. In addition to the 20 gallons of "wash" each animal receives daily, it gets about a ton of hay during the season; this is fed to allow it to chew its cud and keep its bowels in order.

There is a great deal of difference of opinion among Sanitarians on the propriety of feeding animals on "distillery wash" or "dregs." Numerous investigations have been made into its qualities which have led to its being prohibited, as far as milch cows are concerned, in many cities and towns in the States and Britain. The question is still an open one, however.

ABATTOIRS.

No special care or arrangements appear to have been made in the early years of this century to regulate slaughter-houses, as we read that even in such large cities as Paris, London, and Edinburgh these buildings were in the densely populated parts of these cities; that no care was bestowed on them, and that the effluvium arising from them was overwhelming. Napoleon I. passed an edict regulating the abattoirs of Paris, in 1810, which fixed their sites, and on these sites they remain at present. The leading British cities did not bestir themselves in this matter till about thirty years ago.

The arrangements of the Paris abattoirs have been very generally followed, the buildings are placed in rectangular order and consist of the

Echaudoir, or particular division allotted for knocking down the animal.
Bouverie, the spaces, or sheds, where the animals are kept after a journey to rest and cool till the body gets to a normal condition.
Fondeurs, or boiling down houses, for meat unfit for human use, &c.
Triperies, the places used for cleaning the tripe of bullocks, and the fat, heads, and tripe of sheep and calves.

In addition there have been lately added a blood house, where all the blood is coagulated, or treated for the albumen, which is used in

calico printing. In Edinburgh, the blood which was at one time wasted is now sold and brings from £800 to £1,200 sterling per annum.

One of the first requisites for a place intended for the slaughtering of cattle is absolute cleanliness, it becomes an essential to have all appliances connected with abattoirs of the cleanest and most simple and easily-cleaned nature. Vermin must also be excluded from them. In Edinburgh the houses are built of dressed stone, the floors are laid on a layer of Portland cement concrete, twelve inches deep, the surface being paved with large close jointed flagstones; the roadways between the buildings are also laid on cement concrete, the stone blocks being laid in close sets well jointed. All abattoirs are at all times open to the inspection of city health officers, and are supplied with plenty of water for flushing purposes. One of the best substances for abattoir floors is cement concrete, which can be prepared to any degree of surface roughness, to prevent slipping; being homogeneous and of almost indestructible consistence, it will stand any amount of wear and tear, and it is very easily washed and kept clean.

Few of our Canadian cities are well placed regarding abattoir arrangements, there are too many abattoirs mixed up among dwelling-houses, and health-inspectors have not yet the compulsory powers they must have before they can abate these nuisances. The author has learned, with much surprise, that offal is still fed to hogs at many abattoirs, and that there is a decided demand and preference for pork so fed. This reprehensible and dangerous custom cannot be too strongly censured.

The systems adopted in England for slaughtering and handling the carcases, are shewn by the drawings on the wall, and are an enlargement of the arrangements now in use at several pork packing and other factories; this system saves all handling of the meat and preserves it better than in those cases where it has to be carried on men's shoulders to carts, and upon carts to the butcher stalls.*

It is to be hoped that in any new abattoirs to be built in any of our cities, care will be taken to arrange everything with a view to absolute cleanliness, and that a plentiful supply of water will be laid on. Proper buildings can easily be erected for the destruction of all waste

* The abattoir machinery referred to is known as Meiklejon's Patent Abattoir Machinery and Fittings. Further information on this matter can be obtained from the author.

matter, or the conversion of it into chemical manure for which a market can readily be found; by these means what is now a foul nuisance and decided evil can be remedied at a moderate cost, the health of the municipality guaranteed, and much valuable matter now being lost turned into a source of revenue.

In the discussion that followed, Dr. Oldright stated that 50,000 gallons of liquid manure mingled with solid particles are daily carried into Ashbridge's Bay to the detriment of the health of those residing in the vicinity. The slaughter-houses are abominable, and that on the Don is a worse nuisance than Mr. Gooderham's byres. He thought that anything that made life less enjoyable, should, if possible, be done away with, even though it might not be practicable to show that there was a direct connexion between this particular nuisance, and the prevalence of any given disease or class of diseases. He asked the assistance of the Institute to enable the Board of Health to carry certain changes in the law in the general interest of the public.

Mr. George Murray spoke as to the advisability of devising laws for the prevention of such nuisances.

Mr. George Acheson raised the question as to the wholesomeness of meat in which the blood has been allowed to remain.

Mr. Alan Macdougall thought that to feed pigs on animal offal increased their liability to become infested with *cestoidea*, chiefly the *trichina spiralis*.

HYPNOTISM AND ITS PHENOMENA.

BY P. H. BRYCE, M. A., M. B., L. R. C. P. & S. EDIN.

(Read before the Institute on the 11th March, 1882.)

In choosing this subject upon which to base some remarks, I feel how imperfectly anything I may say can serve to convey to you any adequate idea of the strange series of phenomena attendant upon the hypnotic state. My excuse, however, for choosing it must be given in the fact that some months ago a patient came under my charge, after having passed through the hands of several physicians, who had given different opinions as to the real nature of her malady. Seeing her for the first time, I was at once struck by the similarity of her condition and appearance to certain patients I had been accustomed to see in Professor Charcot's wards in the Hospice de Salpétrière in Paris.

Her lower limbs were found in a condition of tonic rigidity, while various clonic contractures were taking place in various other sets of muscles. With the ophthalmoscope I endeavored to make out the vascular state of the retina, but was through her movements unable to do so. To perfect, however, my diagnosis I tried the hypnotizing experiment, and in a short time she had passed into a profound slumber. After she had so passed into a slumber I raised an eyelid, thus allowing light to strike upon the eye, when I found that a state of complete cataleptic rigidity had seized upon that side of the body. My diagnosis was finally made beyond doubt when I found that the slightest pressure over the ovaries, after she was again awake, proved their state of extreme hyperæsthesia by inducing an hystero-epileptic attack which was checked by continued firm pressure upon them. Before me was, in very truth, a case of Hystero-epilepsy, precisely similar to those seen in Prof. Charcot's wards, and which have excited the wonder of all scientific men, who have ever had the good fortune, while in Paris, to visit the wards of Salpétrière.

From the nature of the case it will be impossible for us to study the phenomena of hypnotism without to some extent introducing

other phenomena always present in hypnotic subjects (especially in hystero-epileptics); and since my experience of such is limited only to those persons, who have come under the charge of physicians, I shall leave to the apostles of animal-magnetism to explain the spiritual relations which they ostentatiously assume to exist between themselves and those to whom they communicate the *fluidic* force from their over-charged and hypermagnetic souls.

I have chosen Dr. Braid's word, Hypnotism, in preference to somnabulism as expressing more exactly the condition, and nothing more, which we wish to consider; and further prefer it to Charcot's word of "lethargy," applied to the state, since in our language this word has a meaning hardly applicable to what we wish to express.

Perhaps there is no subject about which have hung more awe-inspiring ideas and morbid curiosity than about this of hypnotism—or if we would rather somnabulism, mesmerism, *aut alter*; and there is no scientific subject at the present time which presents more physiological difficulties or pathological interest than the hypnotic phenomena, attendant upon certain—to use the mildest term—*functional* maladies. It would be foreign to the purpose of this paper for me to enter into any lengthy historical account of the many fanciful ideas, which have grown up around our subject; nor would it be very edifying to re-count the confused mass of credulity, charlatanry, and science, which has in the past, and in many quarters does still form part of the conception associated with the term hypnotism. Still it may be interesting to note that I have found in an edition of Galen that magnets, incantations, &c., are spoken of as therapeutic agents in mental affections; and I may further remark that Charcot has become so convinced that the New Testament demoniacs were persons afflicted with no other than epileptic and hystero-epileptic maladies, that, having witnessed so frequently amongst his own patients paroxysms similar to the recorded ones, he has actually had sketches made illustrative of these scriptural demoniacs. But within the present century we see an outgrowth from these pathological conditions, which have hypnotism as a phenomenon, in that pseudo-science termed variously animal-magnetism, biology, mesmerism, &c. It would seem as if there have been too many persons so filled with love for the extraordinary that when they encounter certain facts apparently inexplicable, instead of endeavouring calmly to search out causes prefer to rest in supernatural

explanations. With such then animal-magnetism has taken its origin. According to them some mysterious, imponderable, yet potent fluid passes from person to person: the manipulator of spirits has, doubtless at first honestly, and then afterward with conscious deception, thought his power over the passive subject of his will to be due to some peculiar magnetic virtue in his own constitution. In such persons has the hydra-headed monster of Spiritualism been conceived and reared; and only recently have scientific men been found brave enough to face credulity and ignorant prejudice, and deal with certain undoubted facts, endeavouring to explain them upon the true basis of physical and psychical science. We shall not trouble ourselves with the empiric consultations and diagnostications of Teste and Deleuze, finding thereby diseases that have never had an existence; nor how Vasseur-Lombard cured cancer by magnetism, nor yet of how diseased plants have been stimulated by its mysterious power to a more vigorous growth; but we shall endeavour, in at most a very imperfect way, to study some of the phenomena of this neurosis, produced, it may be, artificially or by pathological causes.

Defining then our subject, we would say that there are certain persons, mostly females, of such constitution, that they, by certain manipulations, simple or more or less complicated, may be brought into such a neurotic condition as that they may be made to pass into a deep sleep in which they may be kept at will for an almost indefinite number of hours. Such then is the apparently simple fact of hypnotism; but this apparently simple fact, I think we shall see as we proceed, will become one both of very great interest and of much difficulty as regards its explanation.

And first it becomes necessary for us to consider whether in this condition of hypnotism the physical system is in exactly the same condition as in natural sleep. As we all know the factors which enter into the causation of the unconscious state known as sleep are so varied that it is most natural that many explanations have been given of the state. Sömmer, as we know, supported by Pettenköfer and others, believed that sleep means exhaustion of the oxygen of the blood and tissues, which has taken place during the day, and that, when this is again stored up at night in sufficient quantity waking follows. While in all probability the fact of there being a greater consumption of oxygen during the day than at night is probably true, yet we are hardly prepared to accept the theory of

sleep founded on one isolated though comprehensive fact. Dr. Cappie's theory is one which seems to comprise many more of the factors entering into the causation of sleep. Briefly, he says: (1) there is with the growing exhaustion, towards evening, of all the tissues a lessened molecular activity of the cerebral cells, and (2) coincidently therewith a change in the capillary circulation of the brain so that less blood is supplied to the brain, and hence the volume of the brain is less. But (3) this situated within the immobile capsule of the cranium must have the hitherto occupied space, now again filled; hence, as Arthur Durham remarks, the result is that the blood in the venous sinuses is increased. But further, Mr. J. Hilton, F.R.C.S., remarks that the cerebro-spinal arachnoid fluid always equipoises the haemic condition of the brain, and especially of the parts surrounding the ventricles—thus resting the brain; and not only so, but also the relation between this fluid and the blood is always one of unstable equilibrium. But, once more, Dr. Hughlings Jackson has shown that the ophthalmoscopic disc is in sleep always in an anaemic condition. Now all this seems simple enough, yet I doubt not that many abnormal states may arise which will be found difficult to coapt with this theory. However, this theory would further seem to be supported by what we find present in many pathological conditions. Thus we know that in active delirium, dependent upon an hyperaemia and inflammation of the brain, sleeplessness is a common symptom, *e. g.*, acute mania and the early stages of acute meningitis, while again in the later stages of both there is unconsciousness and more or less complete coma arising from venous stasis and effusion of lymph into the cerebral tissues. This in an organ with such an enormous capillary circulation—the encephalon containing, according to Haller, $\frac{1}{5}$ of the total blood of the body—must produce the most disastrous effects upon its functional activity as has been experimentally shown in many ways. Thus pressure upon a portion of brain exposed by a fractured cranium has immediately produced a suspension of its functional activity, thereby inducing unconsciousness. That it is anaemia which has produced this state is evident from the fact that a removal of the pressure brings back immediately functional activity of the part.

Before we endeavour to draw a parallel between the physical conditions of natural sleep and induced hypnotism, we shall try and explain how the anaemia of natural sleep is produced.

First, then, we think it now conceded by all that there is a natural law by which all organic life unconsciously seeks rest, in order as it were to store up energy for the renewal of active functions. As far as we know all animals follow this law: we know as well that plants do. How this takes place in plants we know in the fact that the actinic rays of the sun, aiding the decomposition of carbonic acid by the plant and the assimilation by it of carbon, thereby become the exact idex of this functional activity. Nothing then seems more certain than that man's physical, and likewise intellectual, nature seeks in sleep that rest which enables the various organs to *revitalize* themselves by both lessening the physical waste, and the storing up of new energy. But this process, inherent in the natural constitution of man, must of course be carried on by means of natural processes. What are these? Following out embryogenic changes we must necessarily place nutrition of blood and its renovation first. But since nerve force is that which evolutionary progress has carried to its highest point of development in man, we feel that in adult man it should almost be placed first, so potent a regulator has it become of the processes of nutrition. We may say then that nerve force exists through all the degrees from extreme nerve tension to that of complete nerve relaxation, the various degrees depending upon the ability to assimilate nourishment, derived from the blood and external warmth, light, exercise, &c. Now in trying to explain physical phenomena and the part played by nerve matter in them, it is necessary to proceed with the greatest caution, since we frequently find popular expressions and scientific expressions diameterically opposed to one another. Thus the popular expression for nerve anaemia or nerve debility is nervousness, which in reality ought to mean the very opposite, viz., nerve force; and so a whole series of misused expressions originating in wrong pathological ideas might be given.

Starting then somewhere in the complex circle of cause and effect let us suppose that nerve force is given. Now it seems generally accepted that the ganglionic system of nerves, which especially subserves the functions of organic life, is that too which, by giving nerve supply to the muscular tissue of the blood vessels, regulates the blood supply of a part, either by contraction of the walls lessening the blood supply, or relaxation causing a temporary hyperaemia. (It should be noticed here that the hyperaemia attendant upon inflammation seems to some extent at least dependent upon some morbid

condition of the blood, affecting the vitality of the walls of the vessels; but more probably it is largely due to sensory reflex action of the nerves.) That this latter seems the commoner mode of action would seem to be shown from the fact that emotional influences of joy and pleasure with their opposites of sorrow and anger, produce their regular effects of heightened circulation in the capillaries in the one case, and pallor from spasmodic contraction of the same vessels in the other. We must here add to this the important factor of sympathetic nervous influence directly exerted upon the heart, probably from the vaso-motor centre in the medulla oblongata upon the accelerator ganglion in the one instance, and the depressor ganglion in the other, both of which have their supposed centres in its muscular tissues.

We now would seem to have sufficient data wherewith to proceed in our endeavour to explain the phenomena of hypnotism. We have explained the supposed physical conditions tending to produce sleep. Have we the same present in induced hypnotism? It seems to me that in a large degree we have. It is perfectly well known that the hypnotic state cannot be produced at will in all persons, and in others only with various degrees of ease. It is true, moreover, that persons in whom hypnotism can be produced are almost invariably those of an emotional tendency, or those in whom the equilibrium which in health exists between the cerebral and spinal systems is most readily destroyed—certainly those in whom the sympathetic nervous system is most readily acted upon. Nothing can express our views upon this point more exactly than the quotation of M. Jaccoud's remarks concerning hysteria. He says: "The physiological characteristics of Hysteria depend upon the importance of the opposing relations which exist between voluntary or cerebral innervation, and the involuntary or spinal. The performance of the regular functions of the nervous apparatus depends upon the natural and innate subordination of spinal activity to that of the cerebrum; this established hierarchy (which demonstrates among other things the experimental study of reflex motility) is the absolute condition of the normal harmony of the nervous functions. Now in hysteria this harmonic equilibrium is always broken and always in favour of the spinal cord; thus is produced a disorder which bears fatally upon the collective functions of innervation—a veritable cerebro-spinal ataxia which constitutes and characterizes the decay of cerebral action, and the predominance

of spinal action." He further remarks that the physiologist may produce the same condition in three ways: (1) by exaggerating the excitability of the spinal system by irritation of the centripetal nerves; 2) by exaggerating directly the action of the cord itself; and (3) by suppressing the functions of the brain.

These three conditions have each their pathological analogies, and they contain in themselves the totality of the pathogenic conditions of hysteria. Whatever has been the causation of this malady, he further says, we have always these two fundamental elements united, viz.: (1) the weakening of cerebral action, especially that of the will, and (2) the exaggeration of the automatic or spinal action (hyperkinesie spinale).

Thus we see that in these hysterical patients we have emotional subjects who are readily impressed by whatever may affect the sympathetic system, in other words, who are ruled too frequently by the emotions and too seldom by the will,—or as M. Jaccoud so well expresses it: "There is at least temporarily present a cerebral paresis." Now physiologically what does this mean? It must mean, if we adhere rigidly to the belief that the more or less complete abeyance of functional activity in a part is necessarily dependent upon a corresponding temporary absence of force-producing materials in the part, and, so far as we know, this means arterialized blood. For instance, pallor is an anaemia of the capillaries of the skin; while we have, unfortunately, too many examples showing that the functional activity of an arm or leg depends directly upon its nutrition. Moreover, our best authors give among the causes of hysteria, loss of blood, prolonged lactation, &c. The first of these shows that other than purely female disorders may be causes of this malady, *i. e.*, hysteria may occur in delicate and impressionable males as well as in females.

In claiming the anaemia theory as explaining these states I am perfectly well aware that there are some authorities, notably Brown-Sequard, who are opposed to it as being in many cases a sufficient explanation of either hysteria or epilepsy. I find in notes taken from his lectures on the peripheral irritation of nerves, that his explanation of these pathological conditions is not on the supposition of any slow or sudden unequal distribution of blood to the brain, but that he considers the attacks essentially due to reflex action from peripheral sensations creating impressions upon the brain centres. Then

follows a citation of cases where peripheral irritation induced epileptic attacks. No doubt these cases are facts, but I am inclined to the belief that most, if not all, of them can be explained on the anaemia theory. Let us select one example from many. He cites a case where disease of the supra-renal capsules induced epileptic attacks. Now, here it would seem as if we had present much the same sort of peripheral irritation of the nerves, which we have in ovarian hyperaesthesia, &c.; and each is followed by an attack or paroxysm, due, we have reason to believe, to the irritation to the ganglionic nervous system inducing contraction of the brain, capillaries, &c. But, to proceed, assuming that since the hypnotic state is induced principally in persons of natural or induced emotional tendencies, and that in such there is present more or less of a cerebro-spinal ataxia, *i. e.*, a temporary suppression of will power or cerebral force, we necessarily have present a condition of cerebral anaemia, or the very same physiological condition which Cappie, Durham, Jackson, Schiff, &c., agree, is present in normal sleep.

Let us now refer to some of the conditions which exist in hypnotic individuals. You will remember the hypnotizing experiment used as a diagnostic aid in the case already referred to. The method, as remarked by Prof. Charcot, made use of for inducing the hypnotic state is for the most part immaterial, the subjective state of the patient being apparently the necessary condition. What, however, in most cases seems necessary is a fixity of gaze, or at least some impression made upon the visual organs, which we may consider in the light of an irritant. Thus the patient looking fixedly for a few seconds at a single point, placed a few inches in front, and a little above the level of the eyes, is seen to have the pupils first contract and then soon dilate, with this the eyelids are seen to droop, and the patient simultaneously shows signs of muscular relaxation; the head falls to one side or forward, stridulous breathing supervenes for a few moments, then the patient passes into a profound sleep. Other means, such as looking at a bright piece of silver, the Drummond light, or even closure of the eyelid with slight pressure on the eyeball, have all been used, producing the same results. We are now brought to the exceedingly difficult question of the physiological changes which have here taken place. To physiology, rather than pathology, must we look for our answer. First, then, we recognize the fact that the impression made by light or by pressure is made upon the retina,

thence the optic nerve. Thus, with the light we have the special irritant applied to this nerve of a special sense; and, as proved anatomically as well as by physiological experiments, this nerve reflects its impression along the *third* (3rd) nerve to the iris, through the ophthalmic ganglion, and, as we know, instantaneous iris contraction is the result. But the impression reflected upon this ganglion has for us the highest interest. In it are ganglion cells with fibres connecting with other sympathetic ganglia. Now, however great or little may be the optic sensibility here, we are certain of one thing in these cases, and that is of an extreme hyperaesthesia of the ganglionic nervous system. Since externally in the changes of the iris, we can see the proof of the above supposition, it seems logical for us to assume that the sensation reflected from the optic nerve creates upon the ganglionic system such an impression that it is communicated to the vaso-motor centre—seated in the medulla oblongata—of the cerebral arteries; and that thence is communicated an irritation which causes an instantaneous contraction of the cerebral arteries, (possibly also by the irritation supplied to the depressor ganglion of the heart,) thus creating an anaemia, an abeyance of cerebral functions, and as a consequence the hypnotic state. This hypothesis seems quite the same as the one by which Ferrier accounts for related cases, where from emotional states, as anger, &c., spasm of some of the cerebral arteries has taken place, producing temporary blindness, deafness or aphasia, or which were relieved by the use of the magnet overcoming the spasm. We must not forget to note as a factor in this hypnotizing process, that in all such subjects the will-power has been passing into abeyance, since we have already seen that in proportion, as this is absent the spinal, and certainly the sympathetic, hyper-excitability is increased.

Here again let me quote from M. Jaccoud on "Cerebro-Spinal Irritation," words appropriately describing the condition here present. He says:—"The abnormal excitation of the cerebro-spinal system, causes its first effects to be felt upon the vaso-motor system, whose impressibility is so readily shown by the instantaneous production of pallor and of blushing, whence an anaemia or rather secondary ischaemia, both of brain and cord, which increases the disorder of excitability and transforms it into a persistent condition of irritable feebleness. Both clinical facts as shown by Ferrier and the experiments of Van der Becke, Callenfels, Nathnagel, and Krishaber have

placed these hypotheses in the region of verified facts." How inconceivably impressible is the nerve system to influences, seems to be further substantiated from recent experiments by Jaeger, so wholly new, and, if true, so remarkable that I cannot refrain from a brief reference. To use his own words concerning his experiments with the chronoscope, he says, with reference to neural analysis:—"My discovery relates chiefly to the *gemeingefühl* (collective-feeling, emotions), which by physiologists is distinctly separated from the perception by the senses (the philological difference between soul and mind corresponds exactly to this physiological difference). The essential peculiarity of the *emotions* is that the accompanying functional changes are not limited only to a few anatomical parts of the body, but concern all parts of its muscles, nerves, glands, &c. In other words emotion is a condition of the whole body. Hence it follows that not only the sensory nerves undergo a change, but also the muscular or (*i. e.*, motor) nerves. That which is changed is the nervous excitability, and that which produces these changes are soluble substances which enter into the liquids of the body, and amongst which the volatile ones (odorous) produce the greatest effects. The changes of excitability are indicated by the motor nerves as a quantitative index of the conductibility of these nerves for perceptions. Thus we are enabled graphically to illustrate the peculiarity of the emotions by registering an involuntary movement, viz., that of the heart, since every such substance entering the system affects the rhythm of heart and pulse, and may be measured by the sphygmograph. Thus what the nerve of smell, smells, nerve of taste, tastes, and nerve of sight, sees, are all registered by the muscle nerve. He then gives diagrams of sphygmographic tracings of curves of joy (Jargonelle pears), of anger (rancid butter), of nausea (bad drinking water, &c.). Now, allowing that there is a basis of fact underlying what to many may seem fanciful theorizing, we further see how impressible is the nervous system, as shown time and again by Charcot's method for ending the hypnotic state by simply a puff of breath upon the face of the patient.

From these extended remarks, then, it would seem as if we have something like a definite explanation possible of the causation of the hypnotic state, which we may describe as at least a functional pathological state, having its near analogue physiologically in sleep, but with several additional phenomena superadded; and of all these the

most prominent is a remarkable condition of general hyperaesthesia of the spinal system of nerves. But we must beware of making this a too distinctive phenomenon of hypnotism, since we know that not only are different individuals very differently susceptible to external influences while asleep, but also that the same person at different times sleeps with varying degrees of sensibility to external impressions.

We have now to notice the condition into which the system is thrown during the somnabulistic state. Necessarily it is one in which cerebral force is wholly in abeyance. A most interesting illustration of this is seen in some of M. Charcot's experiments. For instance, a patient whom we may call Marie, is hypnotized; her eyes are opened by the operator, and she is told to look carefully at the bystander, that he is Ernestine, a friend of hers. Her eyes are again closed and her friend Ernestine is brought forward, and in the same manner Marie is told that Ernestine is the bystander. The operator now puffs upon her face and Marie awakes and treats the bystander as Ernestine, and Ernestine as the bystander. This delusion persists a long time unless she is again hypnotized, and the hallucination resolved. As we know, destruction of the cerebrum in frogs not only does not destroy, but seems to augment reflex spinal movements; and since, as we have seen, a hyperaesthesia is more or less constantly present in, at least, *plaques* or parts of the bodies of hypnotic patients, we naturally expect them while asleep to be peculiarly susceptible of external influences. Others again exhibit, what may be deemed truly wonderful, sensibility even while awake to external impressions. A Dr. Cowan, relates in the London *Lancet*, that a patient of his was so sensitive to external impressions, that the flying of a bird past a window with drawn curtains, and with the bed-curtains also drawn, produced in her a sudden jerking of the spinal muscles, extending, if violent, to the hands and legs, and all this without any conscious mental emotion. The same person heard, and was affected by sounds not appreciable to other persons, these sounds producing similar reflex movements to those of sight. Besides such examples we have many other examples of reflex spinal acts, as nausea and vomiting from bad sights or odours, quite apart it may be from any mental emotion. What, however, is most to be remarked in all these cases of undue reflex spinal acts, in these functional maladies at anyrate, is that their force is exactly in

proportion as cerebral influence is in abeyance; and further we notice that the longer this state exists so much the more difficult is it to regain cerebral control over reflex spinal movements. Many instances of this latter fact have been witnessed in the hystero-epileptic patient already alluded to. Thus while examining the eye with the ophthalmoscope I have asked her to look down, up, &c. At times this has been done with ease, while at others no apparent efforts on her part could overcome the ataxia due to the lack of cerebral force over reflex spinal action. Again the hyper-excitability of afferent sensory nerves induced by this condition is in its effects readily appreciated. Let us suppose a patient hypnotized and sleeping quietly, the whole muscular system being apparently relaxed. Here we find that the sensibility is so great that very slight friction along the course of any nerve causes tonic contractures of the corresponding muscles supplied by its branches to take place. This I have frequently witnessed in sets of muscles in all parts of the body. What the pathological condition is, inducing this state is in some instances difficult to explain; but a curious experiment which I had the good fortune to witness in M. Charcot's laboratory would seem to throw some light upon the subject. There was present a patient, very healthy-looking, well developed, of fair complexion, and of sanguine temperament, but one of peculiarly emotional tendencies. The experiment upon her was as follows: She, having been first hypnotized, was sleeping peacefully while sitting in her chair. An assistant now bandaged the right arm, and having tied it above the bandage showed it to be anaemic. Now by slight pressure upon the ulnar nerve at the elbow the form of contracture *en griffe* was set up in the corresponding fingers of that side. A large magnet was then placed in contact with the left arm when, wonderful to relate, there followed a slight muscular tremor in the muscles of the left arm, and thereafter the same contractures took place in the muscles of that hand, the contractures on the right side being correspondingly relaxed at the same time, but by irritation were again induced, there being contractures thus present in both at once. I did not hear M. Charcot's theory as to the causation of this phenomenon, but it seems to me that we have a right to assume that:—(1) anaemia of the right arm made it very irritable and sensible of impressions; (2) when the cerebrum was even slightly impressed it set up motor reflex action and contractions took place; (3) and in the third, and

strangest of all, that of the magnet's influence, we must assume that it, like the static electricity of the plate electric machine produces with its high tension a state of extreme hyperaesthesia, or impressibility, so that the impression made upon the sensory centres from the right arm irritation, is now great enough to excite through the commissural fibres the same reflex action on the left side. But further, it was found that on removing the tourniquet from the right arm the contractures of the left gradually relaxed, and the contractures came back again in the right arm, but slowly and not very completely.

We must confess that we have present what seem to be at first two contradictory phenomena: (*a*) anaemia producing hyper-excitability in one arm, (*b*) while in the other tonic magnetic influence has produced, at least as far as effects go, a similar state of great sensibility.

But though we may fail in fully explaining this peculiar condition, yet I think we can gain at least one step in advance by noticing an explanation given by Dr. Broadbent concerning some of the causes of paralysis from hemorrhage into the *corpora striata* and *thalami optici*. He thinks it can be shown that where the muscles of corresponding parts of the body constantly act in concert the nerve nuclei of these muscles are so connected by commissural fibres as to be *pro tanto* a single nucleus. Now supposing that the magnetic influence has greatly increased the impressibility of the left side we may fairly infer that the reflex action setting forth from the sensorial nucleus which was impressed by the irritation on the right side, and which caused the tonic contraction of muscles in the right arm (being of a certain quantity which we may call x), has been transferred to that muscle having the greater temporary conductibility. Thus we have now relaxation in the muscles of the right arm, and the phenomenon of tonic contraction in those of the left. Let us now remove the temporary stimulus of the magnet and we have the original impression made upon the nucleus, again transferred to the right arm but in a greatly diminished degree, since this side has again become that of greatest excitability.

Before closing there is another condition induced in patients whilst in the hypnotic state so strange—we might say marvellous—and unusual that it demands some few remarks. I refer to the remark already made that, when the one eye of a hypnotized patient is

opened, the impression produced, we must assume, by light induces some new condition by which that side of the body of the patient is thrown into a cataleptic state. Now before inquiring what this change is, it may be well for us to try and explain the pathological condition present in a catalepsy which may attack persons without their first passing into the hypnotized state. At the outset we must confess to the unsatisfactory information which most of our authors give us on the subject. All that even Bristow says is, "that in cataleptics we have a class of cases difficult to classify, and difficult to attach to specific lesions or specific conditions of the nervous system." We do find, however, in M. Jaccoud already quoted from something which really does aid us.

He says:—"Catalepsy is a spasmodic paroxysm and is constituted of two elements: (1) the suspension of cerebral operations, or their external manifestations; (2) the increase of the spontaneous and reflex tonicity (innervation de stabilité) in the muscles of animal life. The abolition of cerebral action presents itself under two forms (rather degrees) which imply different organic localizations: in one (*a*) there is total loss of consciousness, viz., of sensation, perception, ideaism and its consecutive acts, and this can be interpreted only by the inertia of the grey substance of the hemispheres; in the other (*b*) consciousness is not suspended, perception and ideasim are complete, but lack the last link of the chain, *i. e.*, the motor intuition cannot be communicated to the motor apparatus. Here it is clear the cortical substance is normal, but the inertia is in the conductive fibres which bind together the organizing apparatus and the performing apparatus. Nevertheless the result is the same; tonic spasm is present, keeping various sets of muscles in whatever position placed. And this tonic spasm (spasmes du tonics) is a lasting tension. Here we have a most noticeable fact in the marked increase in the innervation of of stability. The tension keeping up this stable condition of the muscles must be looked upon as a reflex phenomenon, provoked by the molecular change (elongation or shortening) which the communicative movements cause the muscles to undergo. It is this molecular change which is the centripetal excitation necessary to all reflex movements; and this stimulus repeats itself every time that the muscle is moved. One difficulty exists in the constant relation which binds the quantity of tension to that of passive movement in such a way that the reflex spasm produced by this latter is always

rigidly adequate to it, and arrests the muscles exactly in the position which one gives to them. Benedikt notes, concerning this point, that according to the researches of Volkmann the contractile capacity of muscle augments or diminishes according as it is shortened or elongated by traction." Evidently, we think, M. Jaccoud has thrown much light on the pathology of the symptoms of catalepsy; but as he says, the causation of the malady is yet obscure;—or, how are produced those opposed states of the cerebral and spinal centres, and why are the symptoms limited to the muscles of animal life?

Referring again to the cataleptic condition associated with the hypnotic state, we ask what changes take place in the system, which by the simple raising of an eyelid effect the change into what M. Jaccoud says is one of increased spontaneous and reflex tonicity?

First, then, in hypnotism the first of Jaccoud's cataleptic postulates is present, viz., the suspension of cerebral operations and their external manifestations. How has it been possible for light to produce all these changes? We have already noted the hyper-excitability of the muscular nerves present in hypnotism, causing muscular contractions when subject to the slightest irritation. We have further supposed that light has been the excitant or irritant inducing sleep with cerebral force in abeyance. Again we must remember the muscular relaxation taking place when hypnotism is induced. Evidently then our assumed nerve spasm has here passed off. But on opening the eye of the patient the excitant is again present with cerebral operations wholly in abeyance; hence we may suppose that the irritant affecting the optic nerve not only renews the spasm previously present and setting out from the sympathetic nerve cells residing in the medulla oblongata, thereby not only making the cerebro-spinal ataxia more complete, but also as a consequence leaving the spinal cord perfectly separated from cerebral influence; and, moreover, having an irritant in the form of light constantly producing a central influence upon it, we have it held in a state accurately defined by M. Jaccoud as *innervation de stabilité*.

But, gentlemen, our already too long paper must be brought to a close. These hypotheses and suggestions are only made by us as possible explanations of a series of phenomena both strange and unusual. It will indeed afford us a real pleasure when advancing medical science will have rescued many of these questions from the mists still enveloping them, and when the pure light of day will be

seen illuminating them as it now does the many common maladies which we daily encounter. Most truly would we express the fervent prayer of Tennyson :

"Let knowledge grow from more to more,"

for to no other as much as to the true physician does this desire come that thereby the sum of human ills may be lessened, and the saddened face of a suffering humanity be illumined, let us hope, with spontaneous gratitude towards a profession which, with all its imperfections, is yet most earnest in the promotion of man's highest mental as well as physical well-being.

Many are the points concerning these neurotic puzzles which we have left untouched ; but it is hoped that other more experienced minds, and pens, wielded by other more facile hands, will take these up, adding thereby to the sum total of that medical knowledge, one of the many glories of the future for, as our Laureate sings,

"And the thoughts of men are widened with the process of the sun."

TO THE BINDER.

Where necessary in Vol. I., place the Plates with the Papers which they illustrate.


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