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Beacon Lights of Science

THE ORIGIN OF THE ARYANS.

AN ACCOUNT OF THE PREHISTORIC ETHNOLOGY AND CIVILIZATION OF EUROPE.

BY

ISAAC TAYLOR,

M.A., Litt. D., Hon. LL.D.

ILLUSTRATED.

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PREFACE.

The last ten years have seen a revolution in the opinion of scholars as to the region in which the Aryan race originated, and theories which not long ago were universally accepted as the well-established conclusions of science now hardly find a defender.

In Germany several works have been devoted exclusively to the subject, but no English book has yet appeared giving an account of the state of the controversy, and embodying the results recently arrived at by philologists, archæologists, and anthropologists.

The present volume does not aim at setting forth new views or speculations. It is rather a summary of the labors of many scholars, and a critical digest of the very considerable literature which has now accumulated on the subject. Its object is to present in condensed form a statement of ascertained facts, and of the arguments which have been based upon them. On the works of four scholars, Cuno, Pösche, Penka, and Schrader,* who deal specially with the subject of this book, I have freely drawn, often without specific acknowledgment. I am more especially indebted to Dr. Schrader's admirable work, which forms an almost exhaustive treasury of facts and arguments set forth in a critical and impartial spirit. To this work, an English translation of which is announced for speedy publication, the student who desires to follow out the subject may be confidently referred.

Of the anthropologists I have relied chiefly on Virchow, the greatest of the Germans, and on Broca, the greatest of the Frenchmen; but without neglecting other writers, such as Rolleston, Huxley, Thurnam, Davis, Greenwell, De Quatrefages, Hamy, and Topinard.

For archæological details constant reference has been made to

*Johann Gustav Cuno, *Forschungen im Gebiete der alten Völkerkunde;* Theodor Pösche, *Die Arier;* Karl Penka, *Origines Ariacæ* and *Die Herkunft der Arier;* O. Schrader, *Sprachvergleichung und Urgeschichte.*

Helbig's little-known but admirable book on the prehistoric civilization of Italy, as well as to the works of Keller, De Mortillet, and Boyd Dawkins.

I have obtruded my own opinions as little as possible. On the main thesis of the book they are essentially those of Spiegel and Schrader, though in several points I find myself rather in agreement with Cuno, whose ingenious work seems to be almost unknown in this country, if one may judge from the fact that I have seen it quoted in no English book, and found that it was unknown even in the British Museum.

I believe the speculation as to the relations of the Basques and Iberians is new. I have also worked out a pregnant suggestion of Dr. Thurnam's—the identification of the primitive Aryans with the "Turanian" race of the British round barrows—an hypothesis which seems to afford the most probable solution of the problem of the origin of the Aryans; and this I have combined with the philological arguments of Anderson, Weske, and Cuno, the only scholars who have effectively investigated the linguistic affinities of primitive Aryan speech.

In the chapter on Mythology, I have attempted to work out, to its legitimate conclusion, a line of argument suggested in the Hibbert Lectures of Professor Rhys.

I. T.

SETTRINGTON,
December, 1889.

THE ORIGIN OF THE ARYANS

CHAPTER I.

THE ARYAN CONTROVERSY.

WHEN towards the close of the last century Sanskrit and Zend became known to European scholars, the new science of Comparative Philology came into existence. The first stone of the edifice was laid in 1786, when Sir William Jones made the memorable declaration that the similarities between Sanskrit, Greek, Latin, German, and Celtic could only be explained on the hypothesis that these languages had a common parentage. Hegel hardly exaggerated the consequences of this discovery when he called it the discovery of a new world.

Fifty years elapsed before Bopp succeeded in establishing, as a settled conclusion of science, what had hitherto been little more than a probable hypothesis. His *Comparative Grammar*, published in 1833–35, has been superseded in its details by other works, and it has now only an historical interest. But to Bopp belongs the honor of having discovered the method of the comparison of grammatical forms, which at once placed Comparative Philology on a scientific footing. In this and subsequent works Bopp showed that Zend and Slavonic, as well as Albanian and Armenian, must be included in what he called the Indo-Germanic family of speech.

The great linguistic family, whose existence was thus established, embraces seven European groups of languages—the Hellenic, Italic, Celtic, Teutonic, Slavonic, Lithuanic or Lettic, and Albanian ; in fact, all the existing languages of Europe except Basque, Finnic, Magyar, and Turkish. There are also three closely related Asiatic groups : the Indic, containing fourteen modern Indian languages derived from Sanskrit ; secondly, the Iranic group, comprising Zend, Persian, Pushtu or Afghan, Baluchi, Kurdish, and Ossetic ; and, thirdly, the Armenian, which is intermediate between Greek and Iranian.

No name, altogether unobjectionable, has been devised for this family of speech. Japhetic, modeled after the pattern of Semitic and

Hamitic, involves the assumption of a descent from Japhet. Caucasian is both too narrow and too broad, and, if used at all, is applicable to race rather than to language. Sanskritic gives undue prominence to one member of the group. Indo-Germanic and Indo-European are not only clumsy, but inaccurate. The first, adopted by Bopp, is a favorite term in Germany; but French and Italian scholars see no reason why German should be taken as the type of European speech. Indo-European, which they prefer, is too narrow, since it excludes Iranian and Armenian, and too broad, since the languages in question are spoken only in a part of India and a part of Europe.

ARYAN, a term invented by Professor Max Müller, is almost as objectionable as Sanskritic, since it properly designates only the Indo-Iranian languages, in which sense it is used by many continental scholars. Moreover, it tacitly implies or suggests that the ancient Ariana, the district round Herat, was the cradle of the Aryan languages, and thus begs the whole question of their European or Asiatic origin. However, since the term has the great merit of being short and compact, and since it is almost universally adopted by English writers, and is increasingly used in France and Germany, it will, in spite of its manifold demerits, be employed in the ensuing pages.

We have already seen that Comparative Philology, as a science, dates from the publication of Bopp's *Comparative Grammar* in 1835. But this great achievement was not without its Nemesis. When Bopp had demonstrated that the greater number of the languages of Europe and some languages of Asia must be referred to a common ancestral speech, there was a tendency to assume, as a matter of course, that the speakers of these languages were also themselves descended from common ancestors. From a primitive unity of speech scholars hastily inferred a primitive unity of race.

Professor Max Müller, owing to the charm of his style, to his unrivaled power of popular exposition, and to his high authority as a Sanskrit scholar, has done more than any other writer to popularize this erroneous notion among ourselves. Thus, in his *Lectures on the Science of Language*, delivered in 1861, instead of speaking only of a primitive Aryan language, he speaks of an "Aryan race," an "Aryan family," and asserts that there was a time "when the first ancestors of the Indians, the Persians, the Greeks, the Romans, the Slaves, the Celts, and the Germans were living together within the same inclosures, nay, under the same roof," and he argues that, because the same forms of speech are "preserved by all the members of the Aryan family, it follows that before the ancestors of the Indians and Persians started for the South, and the leaders of the Greek, Roman, Celtic, Teutonic, and Slavonic colonies marched towards the shores of Europe, there was a small clan of Aryans, settled probably on the highest elevation of Central Asia, speaking a language not yet

Sanskrit, or Greek or German, but containing the dialectical germs of all."*

Than this picturesque paragraph more mischievous words have seldom been uttered by a great scholar. Professor Max Müller's high reputation has been the means of impressing these crude assumptions, which he would now doubtless repudiate, upon his numerous disciples.† In England, at all events, such misconceptions are still widely prevalent, and our popular writers persistently ignore the labors of those French and German scholars who, during the last quarter of a century, have been offering more scientific explanations of the great fact of the fundamental unity of the Aryan languages. They have shown conclusively that the assumption of the common ancestry of the speakers of Aryan languages is a mere figment, wholly contrary to the evidence, and as improbable as the hypothesis that a small Aryan clan in Central Asia could have sent out great colonies which marched four thousand miles to the shores of Europe.

It cannot be insisted upon too strongly that identity of speech does not imply identity of race, any more than diversity of speech implies diversity of race. The language of Cornwall is the same as the language of Essex, but the blood is Celtic in the one case and Teutonic in the other. The language of Cornwall is different from that of Brittany, but the blood is largely the same. Two related languages, such as French and Italian, point to an earlier language from which both have descended; but it by no means follows that French and Italians, who speak those languages, have descended from common ancestors. The most inexperienced eye can distinguish between a Spaniard and a Swede, and yet both speak Aryan tongues, and even in Northern and Southern Germany there is a manifest difference of race, though the language is the same.

The old assumption of the philologists, that the relationship of language implies a relationship of race, has been decisively disproved and rejected by the anthropologists. The ultimate unity of the human race may be admitted, but Professor Max Müller has maintained a nearer kinship of all speakers of Aryan languages. He has asserted that the same blood runs in the veins of English soldiers "as in the veins of the dark Bengalese," and has had the courage to affirm that "there is not an English jury nowadays which, after examining the hoary documents of language, would reject the claim of a common descent and a legitimate relationship between Hindu,

* Max Müller, *Lectures*, 1st Series, pp. 211, 212.

† These opinions are still held by writers of repute. Thus, in 1884, Canon Cook affirmed that "it is a fact, scientifically demonstrated, that the ancestors of all the families belonging to this (the Aryan) race must have dwelt together as one community after their separation from the Semitic and Hamitic branches."—Cook, *Origins of Religion and Language*, p. 312.

Greek and Teuton."* Coming from such a source, this statement cannot be passed over as it might be if it came from a less eminent authority. It will be admitted that the language spoken by the negro in Alabama resembles the language spoken by the New Englander of Massachusetts far more nearly than the language spoken by the English soldier resembles that of the Bengal sepoy with whom he is brigaded, and the evidence derived from the documents of language—in this case not hoary—which might be put before an English jury as to a "common descent," and a "legitimate relationship" between the negro and the Yankee, would be far more intelligible to the twelve English tradesmen in the box than the more obscure evidence which applies to the case of the Teuton and the Hindu. Such rash assertions are calculated to discredit, and have discredited, the whole science of Comparative Philology, and those who have given them the authority attached to influential names must be charged with having retarded for twenty years in England the progress of the science of Comparative Ethnology.†

To the French anthropologists, and more especially to Broca, belongs the credit of raising a needful protest against the overweening claims of the philologists. He observes that "races have frequently within the historic period changed their language without having apparently changed the race or the type. The Belgians, for instance, speak a neo-Latin language; but of all the races who have mingled their blood with that of the autochthones of Belgium it would be difficult to find one which has left less trace than the people of Rome." Hence, he continues, "the ethnological value of comparative philology is extremely small. Indeed, it is apt to be misleading rather than otherwise. But philological facts and deductions are more striking than minute measurements of skulls, and therefore the conclusions of philologists have received undue attention." ‡

These warning words are still neglected, the speakers of Aryan languages are assumed to constitute an Aryan race, and the question is debated, where did this Aryan race originate?

It is now contended that there is no such thing as an Aryan race in the same sense that there is an Aryan language, and the question of late so frequently discussed as to the origin of the Aryans can only mean, if it means anything, a discussion of the ethnic affinities of those numerous races which have acquired Aryan speech; with the further question, which is perhaps insoluble—among which of these

* Max Müller, *Survey of Languages*, p. 29.

† Thus in a recent work Professor Rawlinson quotes the foregoing appeal to the English jury, "from the greatest of modern ethnologists," as the "result of advanced modern inductive science," which has "proved beyond all reasonable doubt" the common origin of the nations which speak Aryan languages.—Rawlinson, *Origin of Nations.* (No. 25 *Humboldt Library.*)

‡ Broca, *La Linguistique et l'Anthropologie*, p. 259.

races did Aryan speech arise, and where was the cradle of that race?

To the same effect, Topinard, a distinguished follower of Broca, remarks that it has been proved that the anthropological types in Europe have been continuous, and if the Aryans came from Asia they can have brought with them nothing but their language, their civilization, and a knowledge of metals. Their blood has disappeared. In France, he continues, we are Aryans only by speech. By race we are mainly Cymry in the north, and Celts in the central region.*

Thirty years ago this question as to the cradle of the Aryan race was deemed a reasonable question to ask, and a possible one to answer. It was even believed that it had received a final and definite solution. European scholars, with hardly an exception, were agreed that the cradle of what they were pleased to call the Aryan race must be sought in Central Asia on the upper waters of the Oxus.

There is hardly a more instructive chapter in the whole history of scientific opinion than that which deals with the arguments on which this conclusion was based, and with the counter arguments which have led, during the last few years, to its general abandonment.

At the beginning of the present century, and even so recently as thirty years ago, the chronology of Achbishop Usher was accepted without question, the origin of the human race being assigned to the year 4004 B. C. It was believed that the primeval language spoken by our first parents was Hebrew,† and that the origin of the languages of Europe must be referred to the family of Japhet, who set forth from the plains of Shinar in the year 2247 B. C.

This theory, based on the belief that the human race originated in Asia at a comparatively recent period, and that the diversity of human speech dates from the confusion of tongues at Babel, was universally accepted. It was maintained, for instance, by Vans Kennedy‡ in 1828, by Dr. Kitto ‖ in 1847, and by Canon Cook § as late as 1884, as well as by a host of less influential writers.

In a somewhat modified form this opinion is still held. Mommsen, in 1874, adhered to the valley of the Euphrates as the primitive seat of the Indo-Germanic race,¶ and the same theory was advocated in 1888 by Dr. Hale, in a paper read before the Anthropological Section of the American Association for the advancement of Science.**

Adelung, the father of Comparative Philology, who died in 1806,

* Topinard, *L'Anthropologie*, p. 444. † Gill, *Antiquity of Hebrew*, p. 44.

‡ Kennedy, *Researches into the Origin and Affinity of the principal Languages of Europe and Asia.*

‖ In Knight's *Pictorial Bible*, vol. i. p. 38.

§ Cook, *Origins of Religion and Language*, p. 314.

¶ Mommsen, *Romische Geschichte*, vol. i. p. 30.

** *Popular Science Monthly*, vol. xxxiv. p. 674, March 1889.

placed the cradle of mankind in the valley of Cashmere, which he identified with Paradise. To Adelung we owe the opinion, which has prevailed so widely, that since the human race originated in the East, the most westerly nations, the Iberians and the Celts, must have been the first to leave the parent hive.

As soon as the archaic character of Zend, and its close relation to Sanskrit, had been recognized, it was seen that the Cashmere hypothesis of Adelung was untenable, and that the Indians and Iranians must at one time have occupied in common some northern region, from which the Indians penetrated into the Punjab. The hypothesis, which for half a century was generally accepted, that Central Asia was the cradle of the Indo-European race, was first propounded in 1820 by J. G. Rhode. His argument was based on the geographical indications contained in the first chapter of the Vendidad, which pointed not obscurely to Bactria as the earlier home of the Iranians.

In view of the enormous extension of time which is now demanded for the evolution and differentiation of the Ayrian languages, these arguments lose their cogency; but they were sufficient to obtain the accession of W. von Schlegel, who nearly at the same time declared himself an adherent of Rhode's hypothesis. But the general acceptance of this theory by European scholars was chiefly due to the great authority of Pott. The reasoning of this eminent scholar is an instructive example of the way in which the imagination can be influenced by a mere metaphor. Pott's argument, if it can be called an argument, is based upon the aphorism—*ex oriente lux*. The path of the sun must be the path of culture. In Asia, he declares, or nowhere, was the schoolhouse where the families of mankind were trained. He fixes on the region watered by the Oxus and Jaxartes, north of the Himalaya and east of the Caspian, as the true cradle of the Indo-European race. Klaproth and Ritter supported this conclusion by a futile attempt to identify the names of the European nations with certain frontier tribes mentioned by Chinese historians. In 1847 Lassen declared his adherence to the view of Pott on the ground that the Sanskrit people must have penetrated into the Punjab from the northwest through Cabul, and that the traditions of the Avesta point to the slopes of the Belurtag and the Mustag as the place of their earlier sojourn. That before their separation the Indo-Iranians were nomad herdsmen, inhabiting the steppes between the Oxus and the Jaxartes, is not improbable, but in view of the philological arguments which establish the comparatively late date of the separation of the Indian and Iranian stems, it is now seen that the admission of a Bactrian home for the Indo-Iranians has little bearing on the question.

In the following year (1848) this opinion received the powerful support of Jacob Grimm, who calmly lays it down as an accepted conclusion of science, which "few will be found to question," that "all the nations of Europe migrated anciently from Asia ; in the vanguard those related races whose destiny it was through moil and peril to struggle onwards, their forward march from east to west being prompted by an irresistible impulse, whose precise cause is hidden in obscurity. The farther to the west any race has penetrated so much the earlier it must have started on its pilgrimage, and so much the more profound will be the footprints which it impressed upon its track."*

In 1859 Professor Max Müller, in his *History of Ancient Sanskrit Literature*, adopted, with sundry poetic embellishments, Grimm's theory of the "irresistible impulse." "The main stream of the Aryan nations," he says, "has always flowed towards the north-west. No historian can tell us by what impulse those adventurous nomads were driven on through Asia towards the isles and shores of Europe. . . . But whatever it was, the impulse was as irresistible as the spell which in our own times sends the Celtic tribes towards the prairies, or the regions of gold across the Atlantic. It requires a strong will, or a great amount of inertness, to be able to withstand such national or rather ethnical movements. Few will stay behind when all are going. But to let one's friends depart and then to set out ourselves—to take a road which, lead where it may, can never lead us to join those again who speak our language and worship our gods—is a course which only men of strong individuality and great self-dependence are capable of pursuing. It was the course adopted by the southern branch of the Aryan family—the Brahmanic Aryans of India and the Zoroastrians of Irân."

On this passage Professor Whitney somewhat maliciously observes that a less poetic and more exact scientific statement would have been preferable, and that the paragraph seems to have been suggested by Kaulbach's famous picture "representing the scattering of the human race from the foot of the ruined Tower of Babel, where we see each separate nationality, with the impress of its after character and fortunes already stamped on every limb and feature, taking up its line of march towards the quarter of the earth which it is destined to occupy."†

Pictet, in his *Origines Indo-Européenes*, of which the first volume was published in 1859, constructed an elaborate theory of the successive Aryan migrations from Central Asia. He brought the Hellenes and Italians by a route south of the Caspian through Asia Minor to Greece and Italy, and the Celts south of the Caspian through the Caucasus to the north of the Black Sea, and then up the Danube to the extreme west of Europe; the Slaves and Teutons marching north of the Caspian through the Russian steppes. Pictet's arguments,

* Grimm, *Deutsche Sprache*, pp. 6, 162.

† Whitney, *Oriental and Linguistic Studies*, p. 95.

derived mainly from philological considerations as to the animals and plants with which he supposed the various races to have been acquainted, vanish on examination.

In the same year Pictet's view was indorsed by a far greater name —that of one of the most acute and profound scholars of the century. So rapidly has science progressed that it seems difficult to believe that so recently as 1862 Schleicher could have propounded, in its crudest form, the theory of the successive migrations of the Aryan races from the East. "The home of the original Indo-Germanic race," he writes in his *Compendium*, "is to be sought in the central highlands of Asia." "The Slavo-Teutonic races first began their journeyings towards the west; then followed the Græco-Italo Celtic peoples; of the Aryans who remained behind, the Indians traveled south-eastward, and the Iranians spread in a south-westerly direction."

The general acceptance in this country of the Central Asian hypothesis is undoubtedly due to the confidence with which, in words already quoted,* it was propounded by Professor Max Müller in his deservedly popular *Lectures on the Science of Language*, delivered in 1861. Stamped with the hall-mark of the approval of the most eminent scholars in Europe—Pott, Lassen, Grimm, Schleicher, and Max Müller—the theory rapidly made its way into all the text-books as an accepted conclusion of linguistic science. Thus Professor Sayce writes in 1874—"When the Aryan languages first make their appearance it is in the highlands of Middle Asia, between the sources of the Oxus and Jaxartes."† It would be tedious to enumerate all the books in which this theory was accepted. Suffice it to say that it was approved by Link, Justi, Misteli, and Kiepert on the Continent, and by Sayce, Muir, Richard Morris, and Papillon in this country.

Before giving an account of the singular revulsion of opinion which has recently taken place, it may be well to examine briefly the arguments which induced the most eminent European scholars, with hardly a dissentient voice, to approve a theory which is now almost as universally rejected.

In 1880, when two daring sceptics, Benfey and Geiger, had already ventured to state the difficulties in the way of the accepted hypothesis, Professor Sayce summed up more forcibly than had been done by any previous writer the reasons why he thought it "best to abide by the current opinion which places the primeval Aryan community in Bactriana, on the western slopes of the Belurtag and the Mustag, and near the sources of the Oxus and Jaxartes."‡

He argues that "Comparative Philology itself supplies us with a proof of the Asiatic cradle of the Aryan tongue." This "proof" consists in the allegation that "of all the Aryan dialects Sanskrit and

* See p. 2, *supra*. † Sayce, *Principles of Philology*, p. 101.

‡ Sayce, *Science of Languages*, vol. ii. p. 123.

Zend may, on the whole, be considered to have changed the least; while, on the other hand, Keltic in the extreme west has changed most." Hence it would appear that the region now occupied by Sanskrit and Zend must be the nearest to the primitive centre of dispersion. This conclusion, he adds, is confirmed by the assertion in the Avesta that the first creation of mankind by Ahuramazda (Ormuzd) took place in the Bactrian region. Professor Sayce admits that "this legend is at most a late tradition, and applies only to the Zoroastrian Persians," but he thinks it agrees with the conclusions of Comparative Philology, which teach us that the early Aryan home was a cold region, "since the only two trees whose names agree in Eastern and Western Aryan are the birch and the pine, while winter was familiar with its snow and ice." He locates it in the neighborhood of the Sea of Aral, to which the universal Aryan myth of the wanderings of Odysseus may refer.

It is fortunate that we should have from such a competent authority a summary of the arguments which, after sixty years of discussion, were considered, only nine years ago, sufficient to establish the Asiatic origin of the Aryan languages.

According to Professor Sayce, the first and most conclusive "proof" is the assumption that Sanskrit and Zend are the most archaic of the Aryan languages, and that therefore the cradle of the Indo-Iranians must also be the cradle of the Aryans.

It is now recognized that the archaic character of Sanskrit and Zend is mainly due to the fact that our knowledge of these languages is derived from documents more ancient than those belonging to any of the languages with which they are to be compared. But if we confine our attention to contemporary forms of speech, and compare, for instance, modern Lithuanian with any of the vernacular dialects of India which have descended from Sanskrit, we find that the Lithuanian is immeasurably the more archaic in its character. It may be surmised that if we possessed a Lithuanian literature of a date contemporary with the oldest literature of India, it might be contended with greater reason than the cradle of the Aryan languages must have been in the Lithuanian region. In like manner it is not fair to compare ancient Zend with modern German. But if a comparison is made between modern Persian and the vernacular Icelandic, the latter is seen to have preserved the more archaic forms, so that if the argument from archaism be admissible, and the argument is confined to these contemporary languages, it would be more reasonable to place the Aryan cradle in Iceland than in Bactria.

But, it will be said, we know Iceland has been colonized within the historic period. True; but we know also that the Indo-Iranians were nomad herdsmen at a time when the European Aryans were no longer nomads, and therefore they might easily have wandered with their herds to Bactria; while the archaic character of the Indo-Iranian speech is explained by the parallel case of the Tartar tribes, which exhibit the conservative influence on language of a wandering pastoral life.

Against the traditions of the Avesta, which are so late as to be valueless, may be placed certain synchronous traditions of the European Aryans that they were themselves autochthonous. The Deucalion legends of the Greeks has as much, or as little value, as the traditions of the Avesta.

The philological deductions as to latitude and climate apply with as much force to Europe as to Asia; and if the birch and the pine were known to the primitive Aryans, so also, it may be urged, was the beech, which, unlike the birch and the pine, is confined to Europe, while the ass and the camel, which were certainly unknown to the undivided Aryans, are especially characteristic of the fauna of Central Asia. As for the Sea of Aral, and the wanderings of Odysseus, they are disposed of by the fact that the words both for sea and salt are not common to the European and Asiatic Aryans, while if a sea is required, the Baltic, for that matter, would serve as well as the Sea of Aral.

It is very instructive to learn how extremely shadowy are the arguments which sufficed to convince all the greatest scholars in Germany and England, Pott, Lassen, Grimm, Schleicher, Mommsen, and Max Müller, that the origin of the Aryans must be sought in Asia, whence, in successive migrating hordes, they wandered to the West. In spite of the intrinsic probabilities of the case, in spite of the enormous difficulties of any such migration, this opinion was universally accepted, on no solid grounds whatever; at first merely from the general impression that Asia was necessarily the cradle of the human race, and afterwards on the authority of a late Iranian legend, aided by the belief, which now proves to be baseless, of the more archaic character of Zend and Sanskrit. There is no more curious chapter in the whole history of scientific delusion. The history of the general abandonment, within the last ten years, of conclusions which had prevailed for half a century, as the first fruits of the new science of Comparative Philology, must now be sketched.

First among the causes which have led to this change of opinion must be placed the evidence as to the antiquity and early history of man supplied by the new sciences of Geology, Anthropology, Craniology, and Prehistoric Archæology. The assumption that man was a comparatively recent denizen of the earth, the traditional belief that Asia was the cradle of the human race, and the identification of the Aryans with the descendants of Japhet, had to be reconsidered when it was recognized that man had been an inhabitant of Western Europe at a time anterior to the oldest traditions, probably before the close of the last glacial epoch.

The geographical centre of human history has now been shifted from the East to the West. The earliest existing documents for the history of mankind come not from Asia, but from Western Europe. The most ancient records of any actual events which we possess are no longer the slabs with cuneiform writing disinterred from Babylonian mounds, but the immeasurably older memorials of successful hunts, preserved in the caverns of the Dordogne, which were inscribed by the contemporaries of the mammoth on the bones and tusks of extinct animals, compared with which the records on Babylonian tablets, or in Egyptian tombs, much more the traditions preserved in the Avesta, are altogether modern. The Iranian traditions may take us back for three, or, happily, for four thousand years, the Babylonian and Egyptian records for four or six thousand at the outside. The new science of Comparative Philology has made possible another science, the science of Linguistic Archæology, which takes us back to a period older than all written records, to an age before the invention of writing or the discovery of metals, when the first rude plough was a crooked bough, and the first ship a hollow log propelled by poles.

From another new science, that of Craniology, we learn that those who now speak the Aryan languages do not belong to one race, but to several, and that the same races which now inhabit Europe have inhabited it continuously since the beginning of the neolithic period, when the wild horse and reindeer roamed over Europe.

The sciences of Prehistoric Archæology and Geology have extended still further the history of the human race, and have shown that in Western Europe man was the contemporary of the mammoth, the woolly rhinoceros, and other extinct pachyderms, and have brought to light from the gravels of Abbeville evidences of his handiwork, dating from a period when the Somme flowed three hundred feet above its present level, and England was still united to the Continent. Man must have inhabited France and Britain at the close of the quaternary period, and must have followed the retreating ice of the last glacial epoch, to the close of which Dr. Croll and Professor Geikie assign on astronomical grounds an antiquity of some 80,000 years.

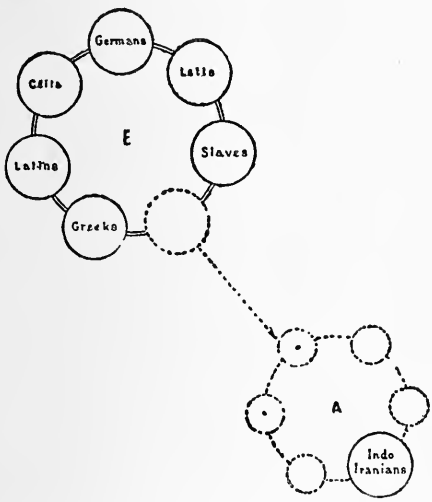
When it was recognized that Europe had been continuously inhabited from such remote ages, it was at once asked whether there is any evidence at all for those great successive migrations from Central Asia which have been so confidently assumed. Is there any reason for supposing that the present inhabitants of Europe are not in the main the descendants of the neolithic races whose rude implements fill our museums? If not, what became of these primitive people? And when the anthropologists succeeded in proving that the skulls of the present inhabitants of Central France are of the same peculiar type as the skulls of the cave-men and dolmen builders who inhabited the same region at the beginning of the neolithic period, when they proved that the skulls of the Spanish Basques belonged to another neolithic type, when they proved that the neolithic skulls from Sweden belong to a third type which is that of the Scandinavians and Northern Teutons, when similar discoveries were made in Denmark, in England, and in Eastern Europe, the conclusion seemed inevitable that the present inhabitants of Spain, France, Denmark, Germany, and Britain are to a great extent the descendants of those rude savages who occupied the same regions in neolithic or possibly in palæolithic times.

It is the anthropologists who have been the chief apostles of the new doctrine, but it must be acknowledged that the first protest against the old assumption of the philologists was raised, before anthropology became a science, by a man who was himself a philologist. To the late Dr. Latham belongs the credit of having been the first to call in question the prevalent belief. As early as 1851, in his edition of the *Germania* of Tacitus, he ventured to assert that no valid argument whatever had been produced in favor of the Asiatic origin of the Aryans. He maintained, on the other hand, that a European origin was far more probable. His argument was two-fold He urged, firstly, that Lithuanian is closely related to Sanskrit, and no less archaic. Sanskrit must either have reached India from Europe, or else Celtic, German, Lithuanian, Slavonic, Greek, and Latin must have reached Europe from Asia. He says he finds no argument whatever in favor of the latter hypothesis, but merely a "tacit assumption" that the human species, and the greater part of our civilization, originated in the East. But if this tacit assumption be rejected, what, he asked, is the most probable conclusion? We find the main body of the Aryans in Europe, and a small detached body in Asia. Which, he argued—and his argument has never been answered—is *à priori* the more probable, that the smaller body broke away from the larger, or the larger from the smaller? The species comes from the genus, and not the genus from the species. To derive the Aryans of Europe from those of Asia would be as reasonable as to bring the Germans from England, instead of bringing the English from Germany; or to derive the reptiles of England from those of Ireland. We find, he argues, two bodies of Aryans, one nearly homogeneous, and of small geographical extent, the other spread over a vast region, and exhibiting numerous varieties. It is more reasonable to suppose that the small homogeneous body branched off from the larger than to assume that the larger parted from the smaller. If we found in Australia a single family of Campbells, and in Scotland a whole clan, it is antecedently more probable that the Australian family emigrated from Scotland than that the Scotch clan came from Australia, leaving only one family behind them.

Latham's argument, extended as it has been by subsequent researches, may be represented graphically by the diagram on this page.

Linguistically the Slaves are closely related to the Letts, and the Letts to the Teutons, as has been shown by Bopp, Zeuss, Schleicher Fick, and Schmidt. The Teutons, again, have been connected with the Celts by Ebel, Lottner, and Rhys; while the relation between the Celts and Latins has been shown by Newman, Schleicher, and Lottner. Again, Mommsen, Curtius, Förstemann, Fick, Schleicher, and Schmidt have shown the connection between Latin and Greek; while the connection between Greek and Indo-Iranian has been established by Grassman, Benfey, Sonne, and Kern. Again, Schmidt, Ascoli, Leskien, and Miklosich have proved the connection between Indo-Iranian and Slavonic. Lastly, Schmidt has shown the absence of cross connections, such as between Greek and Slavonic, or between Indo-Iranian and either Latin or Teutonic.

Hence the European Aryans form a closely-united circular chain of six links; but there is one vacant place—one link is missing from the chain. This missing link is discovered far away in Asia, where we find the Indo-Iranians, who are very closely united with each other, but whose affinities with the European Aryans are chiefly with the Slaves on the one hand, and with the Greeks on the other. They clearly constitute the missing link in the chain, which would be complete in its continuity if they had at some former period occupied the vacant post.



Only two hypotheses are possible. The Aryan languages must either have all originated in Europe around the spot marked E; one member, the Indo-Iranian, separating from the rest, and migrating to its present position, or they must all have originated in Asia, and have been grouped originally around the spot marked A, and then have migrated severally to E, preserving in their new homes the precise relative positions which their mutual connections prove must have originally existed. Which is the more probable hypothesis—that of a single migration, the migration of a people whom we know to have been nomads at no very distant time, or six distinct migrations of six separate peoples, as to which there is no evidence whatever that they ever migrated at all, and whose traditions assert that they were autochthons?

Latham's argument was more conclusive than any that had been advanced on the other side, but it was unheeded. The assumption as to the Asiatic origin of the European peoples was so firmly rooted, and, more than all, was upheld by the authority of such great names, that no one thought it worth while to take the trouble even to reply. His voice was a *vox clamantic in eremo.* He was met, not with argument, but with mockery; and more than twenty years after his book had appeared a learned German thus characterized the fruitful suggestion which has revolutionized the science of Ethnology: "And so it came to pass that in England, the native land of fads, there chanced to enter into the head of an eccentric individual the notion of placing the cradle of the Aryan race in Europe."*

After Latham's views had lain unheeded before the world for sixteen years they received the qualified support of Professor Whitney, who ventured to call in question the Central Asian theory, denying that the traditions in the Avesta had any bearing on the direction of the earliest Aryan migrations, and maintaining that neither language, history, nor tradition had as yet thrown any light on the cradle of the Aryan race.

This was a useful protest, as scholars had not then realized the fact, now generally admitted, that the differentiation of the Aryan languages must have taken place at a period immeasurably more remote than could possibly be reached by the oldest Aryan traditions.

Whitney's position, however, was merely that of an agnostic; he saw that the arguments produced in favor of an Asiatic origin were valueless, but he did not perceive that arguments not without force might be adduced in favor of another solution.

It was only in 1868, after seventeen years of contemptuous neglect, that Latham found his first real disciple—a disciple who did not confine himself to the merely skeptical standpoint of Whitney, and a disciple, moreover, of such eminence that his opinions could not be treated with contempt as merely an amusing illustration of the customary eccentricity of the English. In 1868 appeared the first edition of Fick's *Vergleichendes Wörterbuch der Indogermanischen Sprachen*, accompanied by a preface by Benfey, containing the germ of an argument which has subsequently been greatly developed by other scholars. In this memorable preface Benfey may be said to have originated the science of Linguistic Palæontology. He suggested that the investigation of the vocabulary common to the whole of the Aryan languages might yield a clue to the region inhabited by the Aryans before the linguistic separation. He contended that certain animals, such as the bear and the wolf, and certain trees, such as the beech

* "Da geschah es (Hehn wrote in 1874), dass in England, dem Lande der Sonderbarkeiten, ein originelles Kopf es sich einfallen liess, den Ursitz der Indo-germanen nach Europa zu verlegen."

and the birch, with which the primitive Aryans must have been acquainted, are all indigenous to the temperate zone, and, above all, to Europe, whereas the characteristic animals and trees of Southern Asia, such as the lion, the tiger, and the palm, were known only to the Indians and the Iranians. He urged that the absence from the primitive Aryan vocabulary of common names for the two great Asiatic beasts of prey, the lion and the tiger, or for the chief Asiatic beast of transport, the camel, is difficult to explain on the theory of the migration of the Aryans from the region eastward of the Caspian. That the Greeks called the lion by its Semitic name, and the Indians by a name which cannot be referred to any Aryan root, argues that the lion was unknown in the common home of Greeks and Indians.

Some of these conclusions have been contested, but Benfey's merit was, not only that he indicated a fresh region for research, but that he pointed out the battlefield on which the whole question has since been fought. The great archæological discoveries which took place between 1860 and 1865, especially those of the flint implements in the gravels of the Somme, the Danish shell mounds, the Swiss Lake Dwellings, and the caves in Aquitaine, together with the publication of such works as Lubbock's *Prehistoric Times* in 1865, and of Lyell's *Antiquity of Man* in 1873, could not fail to modify the ethnological assumptions which had been hitherto unquestioned.

Benfey saw clearly that the conclusions of the philologists, by whom alone the question had hitherto been discussed, would have to be revised in accordance with the teachings of the new sciences of geology, archæology, and anthropology. "Since," he says, "the investigations of the geologists have established the fact that from immemorial times Europe has been the abode of man, the whole of the arguments which have been adduced in favor of the migration of the Aryans from Asia fall to the ground." Written, be it remembered, in 1868, this was indeed a prophetic utterance. The revolution in opinion has been brought about by the anthropologists, the philologists merely following tardily in their train.

Benfey's declaration speedily bore fruit, and Geiger forthwith ranged himself in the same camp,* but placing the cradle of the Aryans, not as Benfey had done, in the region to the north of the Black Sea, but more to the north-west, in Central and Western Germany. Geiger's contribution to the argument was not without its value. He bases his conclusions largely on the tree names which belong to the primitive Aryan vocabulary. In addition to the fir, the willow, the ash, the alder, and the hazel, he thinks the names of the birch, the beech, and the oak are specially decisive. Since the Greek φηγός, which denotes the oak, is the linguistic equivalent of the Teutonic *beech* and of the Latin *fagus*, he draws the conclusion that the

* Geiger, *Zur Entwickelungsgeschichte der Menschheit*, pp. 113-150. (Stuttgart, 1871.)

Greeks migrated from a land of beeches to a land of oaks, transferring the name which denoted the tree with "eadible" fruit from the one tree to the other. This argument is as valuable as it is ingenious. The characteristic forest tree of Greece is the evergreen oak, the beech not being found south of Dodona, in the centre of Epirus. The oldest Greek legends are connected with Dodona, where the earliest prophetic utterances were obtained from the rustling of the leaves of this sacred tree. Hence we may believe that the Hellenes entered the peninsula from the north-west through the valleys of Epirus, a route which will explain how the old Aryan word, which originally meant the beech, was transferred to designate the tree which flourished on the hill-slopes of the territory into which they moved.*

The objection that the Greeks must have had a name for the oak before they entered Greece is met by the fact that the word which means "tree" in Sanskrit and Teutonic is used to denote the oak in

* This explanation of the transference of the name seems more probable than the well-known suggestion of Professor Max Müller, that the word originally denoted the oak, and was transferred to the beech at the time when the oak forests of Jutland were replaced by beeches. This would not account for the word *fagus* meaning "beech" in Latin, for the Umbrians had already reached Italy before the age of bronze, while in the bronze age of Denmark, which was later than the bronze age in Italy, the oak was still the prevailing tree, the beech only appearing sporadically. Moreover the replacement of the oak by the beech in Jutland occupied a long period. Had the people of Denmark no name for the beech when it first appeared, and what did they call the oak during the many centuries while it was being gradually replaced by the beech? On the other hand, a people migrating as the Greeks did, from a land of beeches to a land of oaks, would readily transfer the name of the one tree to the other, as in the case of the United States, where the English names of the robin, the maple and the hemlock have been applied to denote wholly different species. The question as to whether the word originally meant the oak or the beech is not unimportant, as, if it denoted the beech, it is difficult to avoid the conclusion that the cradle of the Aryans was west of the beech line. The beech, which is a lover of chalk soils, is not only absent from Hellas proper, but is not found east of a line drawn from the south of Norway to the Swedish coast near Gottenburg, and then from Königsberg through Poland and Podolia across the Russian steppes to the Crimea, and terminating in the Caucasus. Now the name of the beech, transferred by the Greeks to the oak, is common to the languages of the European Aryans, but is absent from the Indo-Iranian languages. Either they lost the name, because, like the Greeks, they had lost the tree, or else their portion of the common home lay east of the beech line. But if, on the other hand, the cradle of the European Aryans, more especially of the Teutonic and Italic families, had been in Central Asia, where the beech is unknown, it is extremely difficult to explain how the ancestors of the Latins, Celts, and Teutons, migrating, as Pictet contends, at separate times, and by different routes, to lands where the beech abounds should have called it by the same primitive name, but modified according to the phonetic laws of Latin and German, the German *b* corresponding to the Latin *f*, and the German *k* to the Latin *g*. The Slavonic name for the beech is a loan word from the German, a fact which indicates that the primitive seat of the Slaves was east of the beech line, just as that of the Latins, Greeks, and Germans must have been to the west of it.

Greek and Celtic. Hence it was only the evergreen oak or ilex to which the name of the beech was transferred. Geiger also maintained that the undivided Aryans must have lived in a cold northern region, since the name of the birch is common to all the Aryan languages, and he contended that the cereals originally known were barley and rye, but not wheat. The word "rye" is common to the Teutonic, Lettic and Slavonic languages, and has been identified by Grimm with the Sanskrit *vrîhi*, rice. But that the primitive meaning was "rye," and not "rice," appears from the agreement of the North European languages with each other, and with the Thracian *βρίζα*. The zone which comprised barley and rye, but not wheat, must be sought somewhere to the north of the Alps, the limit of wheat having doubtless been extended northward since primitive times.

Geiger also argued that the undivided Aryans were acquainted with woad and its use, that they were familiar with snow and ice, and had common words for winter and spring, but none for summer and autumn—facts which all point to a northern habitat. He maintains that no proof has ever been adduced of any Aryan migration from the East to the West, and that on all these grounds the cradle of the Aryans is more probably to be sought in Europe than in Asia. He concludes by saying, "Of the two opposed theories (a European or an Asiatic origin) one only is supported by any reasons ; for the migration from the East not a single argument has been adduced. It is improbable in itself, and well-nigh impossible, if we are to suppose it took place by successive waves." To suppose that a small Aryan tribe first migrated to Europe, and that the various Aryan languages were subsequently developed, is practically equivalent to a European origin.

To Geiger's argument it was replied by Piètrement that there are regions in Asia whose Fauna and Flora conform to the linguistic conditions. Such a region, he thought, might be found in the neighborhood of Lake Balkash and the Alatau. But it was rejoined that this region has always, so far as we know, been the home of Mongolic races, and that the hypothesis of an early Aryan population was purely gratuitous and supported by no evidence, no vestiges of any Aryan population having been discovered in this region, which is too barren and inhospitable to have been the cradle of such a numerous race.

In the same year that Geiger's book was published a noteworthy contribution to the discussion was made by Cuno,* who contended that the undivided Aryans, instead of being a "small clan," must have been a numerous nomad pastoral people inhabiting an extensive territory. A long period—several thousand years—he considered, must have been occupied in the evolution of the elaborate grammatical system of the primitive speech, while the dialectic varieties out of which the Aryan languages were ultimately evolved could not have arisen

* Cuno, *Forschungen im Gebiete der alten Völkerkunde.* (Berlin, 1871.)

except through geographical severance. The necessary geographical conditions were, he thought, a vast plain, undivided by lofty mountain barriers, by desert tracts, or impassable forests, together with a temperate climate, tolerably uniform in character, where a numerous people could have expanded, and then, in different portions of the territory, could have evolved those dialectic differences which afterwards developed in the several Aryan languages.

There is only one region, he contends, on the whole surface of the globe which presents the necessary conditions of uniformity of climate and geographical extension. This is the great plain of Northern Europe, stretching from the Ural Mountains over Northern Germany and the north of France as far as the Atlantic. In this region, he thinks, and no other, the conditions of life are not too easy, or the struggle for existence too hard, to make possible the development of a great energetic race such as the Aryans. At the beginning of the historic period we find this region occupied by the Celtic, Teutonic, Lithuanic, and Slavonic races, whom he regards as autochthonous. At some earlier time he considers that the Italic and Hellenic races had extended themselves to the South across the mountain chain of Central Europe, and the Indo-Iranians had wandered with their herds further to the East, subduing and incorporating non-Aryan tribes.

To this it might be replied that the steppes of Central Asia, extending eastward of the Caspian for more than a thousand miles beyond Lake Balkash, also offer the necessary conditions, and that here the great Turko-Tartaric race has grown up, presenting an actual picture of what the Aryan race must have been in the early nomad stage of its existence. But it must be conceded to Cuno that the conditions of climate, of soil, of greater geographical extension, and of proximity to the regions now occupied by the Aryans, are arguments for selecting the European rather than the Asiatic plain as the probable cradle of the Aryan race.

It will hereafter be shown that Craniology, Archæology, and Linguistic Palæontology, sciences with which Cuno had a very limited acquaintance, have supplied remarkable confirmations of his hypothesis.

Cuno was not only the first to propound what must be regarded as the most probable solution of the problem, but he was also the first to insist on what is now looked on as an axiom in ethnology—that race is not co-extensive with language. The existing extension of Aryan speech is, he contends, largely the result of conquest and of the incorporation of unwarlike tribes by the more energetic northern races. By reason of their language, he says, we now class the Spaniards among the Latin races, and yet how small is the trace of Roman blood in Spain. It is the same in France, Belgium, and Roumania. In these regions neo-Latin languages prevail, but there is very little

Latin blood, in some cases practically none. How much common blood, he asks, is there in the veins of Teutons and Hindus, or of Celts and Persians, or of Russians and Spaniards, and yet all these nations speak closely-related languages, which we call Aryan.

The southern and eastern extensions of Aryan speech may therefore be due to Aryan conquest, or to the gradual expansion of Aryan civilization over contiguous tribes, and there is therefore no difficulty in regarding the great plain of Northern Europe as the region in which the Aryan race originated.

Cuno then goes on to note that a large portion of North-Eastern Europe is now, or has been in historical times, occupied by Finns. Between Finnic and Aryan speech the relations are intimate and fundamental. They show themselves not so much in vocabulary as in the pronouns, the numerals, the pronominal suffixes of the verb, and the inner morphological structure of language. The extreme members of the Ural-Altaic family, such as the Finns and the Mongols, are separated by differences almost as wide as those which divide Finnic from Aryan speech.

The conclusion he draws is not, however, the obvious conclusion that the Finnic tongues may represent a form of speech out of which the Aryan languages might have been evolved, but that the Finns and Aryans must have been originally in contact, so that if we bring the Aryans from Central Asia we must also find room for the Finns in the same region.

What Cuno failed to notice, though it lay ready to his hand, is the probability that the dialectic differences in Aryan speech may be largely due, not, as he thought, merely to geographical separation, but to the imperfect acquirement of a strange language by those non-Aryan tribes which were Aryanized by conquest. This pregnant suggestion is due, as we shall presently see, to another writer.

Cuno's most important contribution to the controversy was his demolition of the assumption that Aryan blood must be co-extensive with Aryan speech. Another gratuitous assumption, the whole theory of the successive migrations of Aryan tribes from the East, was swept away in the following year by Johannes Schmidt in a pamphlet of sixty-eight pages.* A pebble from the sling of a shepherd boy smote down the Philistine giant, and in like manner this little essay, by a young and almost unknown writer, made an end of the huge structure which had been painfully reared by some of the giants of philology. If, as had been hitherto supposed, the ancestors of the Aryan nations—Celts, Teutons, Lithuanians, Slaves, Latins, and Greeks—had, one after the other, left the parent hive, and had marched in successive or associated swarms from Central Asia to find new homes in Europe,

* Schmidt, *Die Verwantschaftsverhältnisse der Indogermanischen Sprachen.* (Weimar, 1872.)

it would manifestly be possible to construct a pedigree in the form of a genealogical tree, representing graphically the relationships and affiliations of the Aryan languages, and their connection, more or less remote, with the parent speech. For twenty years philologists had occupied themselves in the construction of such trees, but no two of their schemes agreed. Bopp, Pott, Grimm, Lottner, Schleicher, Pictet, Zeuss, Fick, Förstemann, Grassmann, Sonne, Curtius, Max Müller, Pauli, Spiegel, Justi, Ebel, were hopelessly at variance as to the ramifications of the supposed Aryan tree, a matter which, if an Aryan family had really existed, ought to have been susceptible of exact determination. There was a fundamental difference of opinion as to whether Slavonic was to be classed with the European or the Asiatic languages, whether it was a sister tongue of German or of Zend, and there was a similar dispute as to the relationship of Greek, some scholars considering it to be most closely allied to Latin ; and others maintaining that the relationship was with Sanskrit, while opinions were divided as to whether the separation of the Celts was very early or very late, and whether their nearest affinities were with Latin or Teutonic. There was also a fundamental difference of opinion as to whether the earliest cleavage was between the Northern and the Southern languages, or between the Eastern and the Western, and also, as has been said, as to whether Greek and Slavonic must be classed among the Eastern or the Western tongues.

This *stammbaum* controversy, as it was called, which seemed to be interminable, received a solution as complete as it was unexpected. Schmidt's pamphlet placed the whole matter on a new footing. The disputants were shown that none of their apparently irreconcilable opinions as to the affinities of the Aryan languages were necessarily wrong, but that the method of representing those affinities by a genealogical tree must be given up. Schmidt asserted that the relationship could not be represented by the branches of a tree, but were analogous to the waves caused by disturbances in a pond. He supposes that at some early period the geographical continuity of the primitive Aryan speech was unbroken. At certain points in this area local centres of disturbance arose, and new linguistic formations, or new phonetic variations, began to manifest themselves, and then spread, like waves, in every direction from the point where they originated, the disturbances growing feebler the further they extended, in the same way that concentric wave-circles arise when stones are dropped into still water at parts more or less remote. These waves would spread in concentric circles round the centres of disturbance, till at length they interfere. In this way, he thought, the difficulties could be explained, and the opposite contentions at last be reconciled.

The two chief points which had been disputed between the partisans of rival "trees" were, as we have seen, whether Slavonic was a branch from the Iranian or the Teutonic stem, and whether Greek had bifurcated from Latin or from Sanskrit. Schmidt showed that Greek was in some respects as closely united with Sanskrit as it was in others with Latin, while Slavonic shared certain peculiarities only with Teutonic, and others only with Iranian. Schmidt also showed that the more geographically remote were any two of the Aryan languages, the fewer were the peculiarities they possessed in common. Thus, while there are fifty-nine words and roots peculiar to Slavo-Lithuanian and Teutonic, and sixty-one to Slavo-Lithuanian and Indo-Iranian, only thirteen are peculiar to Indo-Iranian and Teutonic. Again, while one hundred and thirty-two words and roots are peculiar to Latin and Greek, and ninety-nine to Greek and Indo-Iranian, only twenty are peculiar to Indo-Iranian and Latin. Hence Slavonic forms the transition between Teutonic and Iranian, and Greek the transition between Latin and Sanskrit. Schmidt successfully contended that the notion of a genealogical tree must be entirely given up. There must at one time, he thought, have been an inclined plane of language, sloping continuously over the whole domain of Aryan speech from East to West—from Sanskrit to Celtic. At various points dialectic differences arose, and then, owing to political, social, or religious causes, certain local dialects obtained predominance and developed into languages, exterminating the weaker intermediate dialects In like manner Attic exterminated the other Greek dialects, and the dialect of Rome absorbed Oscan, Umbrian, and the other Italic dialects. Thus, he thought, the inclined plane of Aryan speech was broken up into steps and converted into a staircase.

Schmidt's theory of the origin of the Aryan languages resembled Darwin's theory of the origin of species. Languages were due to some unknown tendency to variation, coupled with the extermination of intermediate varieties, and the survival of the prepotent. This principle has recently been ably developed by Professor Paul in his *Principien der Sprachgeschichte.*

Schmidt's argument was plainly fatal to the old theory of successive separations and migrations from the East. It was manifest that the linguistic differences must have arisen *in situ* at a time when the Aryan nations occupied much the same relative geographical positions as they do now.

Leskien improved on Schmidt's theory by introducing the element of relative time. It was not necessary, he maintained, to suppose that all the disturbances were simultaneous. One disturbance, for instance, might have affected the Teutonic region and spread to the contiguous Slaves, and then, after the Slaves and Teutons had become separated, another disturbance might have affected the Slaves and spread to the Iranians. Penka afterwards suggested a *vera causa* for these disturbances, which Schmidt had considered to be arbitrary or accidental.

Combining Cuno's theory with Schmidt's, he argued that as the primitive Aryans must have incorporated many non-Aryan races, the dialectic differences may be due to these incorporations. For instance, the peculiarity shared by Lithuanians and Slaves may be due to the incorporation of Finnic tribes, and those common to Slaves and Iranians to the incorporation of Ugrians. That there may be some truth in this explanation is shown by the fortunes of the neo-Latin languages. It is highly probable, for instance, that some of the differences which distinguish French and Spanish may be due to the fact that in one case Latin was a foreign language acquired by Celts, and in the other by Iberians.

The loss of inflections in French and Persian was largely due to the difficulty felt by Frankish and Arab conquerors in acquiring a foreign tongue. English has been similarly affected—first by the coalescence of Saxon and Anglian speech, and then by the influence of the Danish and Norman conquests and the preaching of the Franciscan monks. In the process it has lost its genders and four of its five cases, while of the six ways of forming the plural all were lost but one. In like manner, when we find that Latin lost three of the old tenses, and formed a new future, a new perfect, a new imperfect, and a new passive, we have to take into account the possibility of the incorporation by Aryan invaders of a non-Aryan population.

But the influence of these theories was more far-reaching than their advocates had supposed. The ultimate result has been to bring about a conviction not only that there is no such thing as any pure Ayran race, but that the existence of a primitive Ayran language is doubtful.

In 1880 Delbrück,* after discussing the *stammbaum* theory, and the theories of Schmidt and Leskien, came to the conclusion that there had never been, as had been universally assumed, any uniform primitive Aryan speech. The development of the inflections must have occupied, he thinks, many thousand years, and the Aryans, before the grammar was fully developed, must have become a very numerous people, occupying an extended territory, within which vast region diversities of speech must have originated. These diversities were the germs of some of the differences which now separate the families of Aryan speech. In short, the primitive Aryan speech had begun to break up into dialects before it was fully formed.

The publication in 1871 of the books of Geiger and Cuno marked the beginning of a new era in the controversy. Up to this time the Asiatic origin of the Aryans had been the orthodox view which it was a scientific heresy to doubt. The Asiatic or the European origin now

* Delbrück, *Einleitung in das Sprachstudium*, pp. 131-137.

became an open question, and the ensuing decade was a period of unceasing strife between the partisans of the rival theories. Year by year the adherents of the old hypothesis became fewer and less confident, while the European theory found fresh advocates among the younger generation of scholars.

Höfer repeated the old argument, that since the most archaic forms of Aryan speech are preserved in the Rig Veda and the Avesta, the cradle of the Aryans must have been in the region where Sanskrit and Zend were spoken—an argument already answered by Whitney with the remark that among existing languages Icelandic and Lithuanian preserve the primitive forms of Aryan speech more faithfully than the Armenian or the Kurd.

Piètrement revived once more the argument from the geographical traditions of the Avesta, which may be valid for the later migration of the Iranians, but not for those of any other race, or even for the earlier migrations of the Iranians.

Kiepert and Hehn followed with the contention that Asia is the true *officina gentium*, and that the analogy of other migrations from East to West makes it difficult to believe that the earliest and greatest of all took place in the opposite direction. Is it credible, says Hehn, that the oldest forms of Aryan speech are to be sought in the woods and swamps of Germany rather than in the literary monuments of India and Bactria?

To this it might be replied—if indeed mere rhetoric requires a reply—that if Ghengiz Khan marched from Bactria to Europe, Alexander marched from Europe to Bactria; and that if Tamerlane led his army westward to Galatia, the Galatians themselves had marched eastwards from Gaul to Galatia; while, if Germans and Slaves at one time extended their border to the West, they have now for several centuries been extending it to the East.

The logical weakness of the Asiatic hypothesis cannot be better shown than by the fact that a zealous and able advocate like Hehn was driven to resort to such feeble analogies in lieu of solid argument.

Perhaps the strongest argument that has been adduced in favor of the Asiatic origin of Aryans is that which has been drawn by Hommel, Delitzsch, and Kremer, from certain supposed primitive relations between Aryan and Semitic speech. That the Semites originated in Asia may be admitted, and if any fundamental connection could be shown between the Aryan and Semitic languages there would be reason to suppose that the cradles of the two races must be sought in contiguous regions. Hommel adduces six culture words which, he thinks, establish such a primitive connection. But six words are not enough to base a theory on; the phonetic resemblances may be accidental, or the words may be very early loan words due to Phœnician commerce. This is probably the case with the names of silver, gold, and wine, which, as will hereafter be shown, there is reason for believing, on archæological grounds, to have been unknown to the early Aryans.

Delitzsch goes deeper. He claims to have identified one hundred Semitic roots with Aryan roots. But even if these identifications be accepted, it would not suffice, as it would be also necessary to show an agreement of grammatical formative elements; and it is universally admitted that in grammatical structure the Semitic and Aryan languages differ fundamentally. The agreement of certain primitive verbal roots, if they do agree, may, possibly, be otherwise explained. The speakers of Aryan languages are not all of Aryan race. It will hereafter be shown that the Mediterranean race of Southern Europe was probably Berber or Hamitic. A remote connection between the Semitic and Hamitic families is generally admitted, and there are numerous verbal roots which seem to be common to the Hamitic and Semitic languages. If the Southern Aryans are only Aryanized Hamites, it would account for fundamental differences in Semitic and Aryan grammar co-existing with certain coincidences of Semitic and Aryan roots.

In spite of these objectors, possibly because their objections were so feeble, the new doctrine continued to gain adherents. In 1873 Friedrich Müller admitted the force of the arguments for a European origin which had been adduced by Benfey and Geiger from the names of animals and plants common to the Aryan languages. About the same time Spiegel also combated the arguments drawn from the traditions in the Avesta, and urged that it was impossible to believe, with Monier Williams, that a region so lofty, so barren, and so inhospitable as the Pamir could have produced such vast swarms of men as the theory of an Aryan migration would demand, or that they could have vanished without leaving a trace behind; and he declares his adhesion to the view that the cradle of the Aryans must be sought in Europe between the 45th and 60th parallels of latitude.

In this region, he maintains, is a land well suited for the development of the primitive Aryan race. Here we may find room for their expansion, both to the East and to the West, an expansion in which migration, properly so called, played a very insignificant part. The Aryan race, he continues, must constantly have extended itself, including within its domain other races, owing to whose absorption there arose dialectic varieties of speech, which, in course of time, aided by geographical severance and the absence of a literature, gradually developed into separate languages. No more rational theory, it may be affirmed, than this of Spiegel has yet been advanced to account for the origin of the Aryan languages.

Pösche, in a monograph devoted to the controversy,* was the first

* Pösche, *Die Arier, Ein Beitrag zur historischen Anthropologie.* (Jena, 1878.)

to bring forward the anthropological argument, which has since been developed by Penka. He maintained that anthropology and archæology must supplement and correct the conclusions of philology. He urged, as Broca had urged before, that, while there may be Aryan languages, there is no such thing as an Aryan race, and that language is only one, and that the least important factor in the inquiry, and that, while Aryan languages are spoken by races wholly unrelated, there is only one race, the tall, blue-eyed, fair-skinned German race, with abundant beard and dolichocephalic skull, which can claim to be genuine Aryans by blood as well as by language.

Pösche identified this race with that whose skeletons are found in the Alemannic "row-graves" of Southern Germany, and he contended that it has existed in Europe since the neolithic period. This argument was discredited by his theory, which has not found favor with anthropologists, that the Aryan race originated in the great Rokitno swamp, between the Pripet, the Beresina, and the Dnieper. Here depigmentation or albinism is very prevalent, and here he considers the fair white race originated In this swamp, he thinks, lived the pile-dwellers who afterwards extended themselves to the Swiss lakes and the valley of the Po. The archaic character of the neighboring Lithuanian language induced him to believe that the Lithuanians were a surviving relic of this oldest Aryan race.

The obvious objections to this theory are that the Rokitno swamp is not sufficiently extensive for the cradle of such a numerous people, and that the Aryans, an athletic and energetic race, exceeded in vital force by no other people, could hardly have originated in an unhealthy region, where the conditions of existence are depressing, while the sickly, tow-haired albinism which prevails in the Rokitno swamp is quite different from the tawny hair and the ruddy, healthy, lily and carnation tint of his typical Aryans. Moreover, there is good reason for believing that the primitive Aryans were nomad herdsmen, an occupation unsuited to the conditions of the Rokitno swamp.

Two years later the European hypothesis received the adherence of Lindenschmit, who considers that "we must give up the idea of an Aryan migration from the East as an old delusion derived from historical traditions."* He comes to the conclusion that there is no specially oriental character in the common vocabulary of the primitive Aryans, and he agrees with Benfey in thinking that the absence of primitive Aryan designations for the elephant and the camel, the lion and the tiger, is a strong argument against an Asiatic origin. He also combated, with well-chosen instances, Hehn's argument that the direction of conquest and migration has always followed the movement of the sun from east to west.

He argues that the vital energy and the power of expansion of the

* Lindenschmit, *Handbuch der deutschen Alterthumskunde*, 1880, p. 5.

European Aryans is unique. They are long-lived and possess great muscular force, and hence the cradle of such a tall, powerful, energetic race is not likely to have been in Asia, which has not, so far as we know, developed great physical capacity. He thinks the case of the Goths, the Scandinavians, the Normans, the Scotch, the English, the Germans, and the Dutch, who have overrun the South, who have colonized America, and ruled vast territories in Asia, teaches us that it is in Northern Europe only that we find, in its highest development, the characteristics of the energetic Aryan race. Where these characteristics are now chiefly developed is probably the region where they originated.

Fligier followed in 1881 with a repetition of Cuno's argument as to the primitive connection of the Finnic and Aryan languages, from which he drew the conclusion that the true *vagina gentium* is to be sought in Eastern Europe.

A new epoch in the discussion opened in 1883 with the publication of two remarkable books, which have brought the whole question again into prominence, and have exerted a decisive influence on public opinion. The first of these was a slashing but somewhat one-sided work by Karl Penka,* somewhat feeble from the philological side, but in which the anthropological arguments advanced by Pösche were restated with considerable force. The second, by far the most important book which has yet been written on the subject, was the exhaustive treatise by Dr. Schrader,† which contains a cautious and judicial statement of the whole case.

As many of the arguments and facts adduced by these writers will be reproduced in the following chapters, it will only be necessary, in this historical summary, briefly to state the conclusions at which they have arrived.

In his *Origines Ariacæ*, and in a subsequent work‡ in which he replied to his critics, and brought forward fresh facts and arguments in support of his views, Penka maintained that Aryan blood is far from being co-extensive with Aryan speech. He proved that those who employ Aryan languages belong to several distinct anthropological types. The primitive Aryans must, however, have been of only one race. Either the physical types must have been developed subsequently to the linguistic separation, or Aryan speech must have been acquired by races not of Aryan blood. The former supposition is most improbable, knowing, as we do, the persistency of type displayed during thousands of years by the Egyptians, the Negroes, and the Jews.

* Penka, *Origines Ariacæ*. (Wien, 1883.)

† Schrader, *Sprachvergleichung und Urgeschichte*. (Jena, 1883.) From the proof-sheets of the forthcoming revised edition of this book an English translation by Mr. F. O. Jevons is announced for early publication.

‡ Penka, *Die Herkunft der Arier*. (Wien, 1886.)

The latter supposition is inherently probable, as there are numerous instances of change of language being effected without any change of race. Language, in short, is mutable, race persistent. The question therefore arises, which of the five or six types found among the speakers of Aryan languages represents most faithfully the type of the primitive Aryans? Penka contends that the purest blood is found in Scandinavia among the fair-haired, blue-eyed, dolichocephalic Swedes. The pure Aryans, he maintains, are represented only by the North Germans and Scandinavians, a most prolific race, of great stature, muscular strength, energy, and courage, whose splendid natural endowments enabled it to conquer the feebler races to the East, the South, and the West, and to impose its language on the subject peoples. That the nations of Central and Southern Europe exhibit hardly any traces of the fair northern blood is due, he believes, to the tendency of mixed races to revert to one of the original types. He contends that the northern race, which is prolific in cold climates, becomes sterile in southern latitudes, and ultimately dies out; while the fact that among the Southern Aryans the nobles are fairer and taller than the peasants is an indication of conquest by northerners.

To take an instance from historical times, we see how completely in Italy and Spain the blood of the fair-haired Gothic conquerors from the Baltic has died out, while in Sweden, Northern Germany, and the north of England, the fair type survives because the climatic conditions permit of its preservation. The influence of climate has exterminated the Aryan race in India, Persia, Greece, Italy, Spain, France, and Southern Germany, the Aryan speech alone being left as the permanent evidence of early Aryan conquest.

Penka has undoubtedly weakened his argument by the unnecessary contention that Scandinavia was the cradle of the whole Aryan race. It is difficult to believe that a sufficiently extensive area for the growth of such a numerous people can be found in the forest-clad valleys of Norway and Sweden, which moreover are unadapted for the habitation of a nomad pastoral people, such as the primitive Aryans must have been. Isolated valleys, moreover, tend to the rapid growth of dialects, unity of language being the result of the wanderings of nomad tribes over an extensive plain. In mountain regions like Switzerland and the Caucasus, the people of contiguous valleys speak different languages, while the same language extends over vast regions in the steppes of Central Asia. Penka would have done better to have adopted Cuno's argument, and to have placed the cradle of the Aryans in the great plain of Northern Europe, from which a later emigration to Scandinavia might easily have taken place. This would also have avoided the objection that the primitive Aryans could hardly have possessed the means of migrating across the Baltic in the vast swarms which the hypothesis demands. Sweden is almost as unsuited for the cradle of the Aryans as the Rokitno swamp suggested by Pösche.

We shall, however, hereafter see that the tall, fair Scandinavians are not the only tall, fair people which may represent the ancestral Aryan stock, and that many of the difficulties—geographical, linguistic, and anthropological—which beset Penka's theory disappear at once if we assume that the Celtic race of Central Europe, rather than the Teutonic race of Scandinavia, are the lineal descendants of the primitive Aryans.

Penka also, as we have already seen, accounts for the differentiation of the Aryan languages by a development of Spiegel's theory, which he works out with much ingenuity, that each conquered race, on acquiring the language of its conquerors, would leave upon the acquired speech the impress of the language that was lost.

Of higher quality in every respect is the book of Dr. Schrader, which must long remain the standard work on the subject, as Dr. Schrader reviews, in a judicial spirit, the arguments of preceding writers, and collects in a convenient form the philological and archæological materials on which the solution of the question must be based. The chief defect of Dr. Schrader's work is that, being chiefly a philologist, he leaves out of account those anthropological considerations which are no less important than the archæological and linguistic arguments.

The materials accumulated by Dr. Schrader will, however, be so freely drawn upon in the ensuing pages that it will not now be necessary to do more than briefly to state the final conclusions at which he has arrived, and which, it may be added, are substantially those of the present writer.

In discussing the question of the origin of the Aryans, Dr. Schrader thinks there are two fixed points which may be regarded as settled. At the earliest period to which the evidence of history, tradition, or linguistic archæology extends, we find the European Aryans in Northern Europe, and the Asiatic Aryans on the Jaxartes.

As for the European Aryans, he considers that not a particle of evidence has been adduced in favor of any migration from the East. At the earliest time to which the evidence reaches they seem rather to have been extending themselves towards the South and the South-East, and it would appear that the region occupied by them before the linguistic separation must be sought north of the Alps. The precise region can, he thinks, be approximately indicated. The beech does not now grow east of a line drawn from Königsberg to the Crimea, and its northern limit must formerly have been still more restricted. Hence the cradle of the Latin, Hellenic, and Teutonic races, which had the same name for this tree,* must have been to the west of the

* See p. 16, *supra*.

ancient beech-line. But since the Slavo-Lithuanian name is a Teutonic loan-word (old Slavonic *buky*, Russian *buk*, Lithuanian *bukas*), we must place the cradle of the Lithuanians and the Slaves to the east of this line. But since there are philological reasons for believing in the unbroken geographical continuity of the European Aryans previous to the linguistic separation, they must be placed in Northern Europe astride of the beech-line; the Slavo-Lithuanians in European Russia; and the Celts, Latins, Hellenes, and Teutons farther to the West.

As for the Indo-Iranians, there can be no doubt, Dr. Schrader thinks, that the Sanskrit-speaking race entered India from the North-West. In the Vedic period they lived on the banks of the Indus, and had only an indirect knowledge of the Ganges. But the Indians and Iranians must previously have formed a united people somewhere to the north of the Himalaya. Both branches retained traditions of the Jaxartes, the greatest river of this region, and on the banks of this stream we must place their earlier seat.

Hence, in our investigations as to the origin of the undivided Aryans, we have these two fixed points—the earliest known seat of the European Aryans was in Northern Europe, and that of the Asiatic Aryans on the Jaxartes.

The only question which remains is whether the European Aryans came from Asia, or the Asiatic Aryans from Europe?

For the solution of this question Dr. Schrader submits six points for consideration—

(1) The old assumption, that because the Indo-Iranian speech is more archaic than the European, therefore the cradle of the Aryans was towards the East, must be given up, because our knowledge of Zend and Sanskrit dates from an earlier period than our knowledge of the European languages. He thinks, moreover, that the greater rudeness of the European languages is itself the sign of a more primitive condition than the literary culture exhibited by Zend and Sanskrit.

(2) The results yielded by Linguistic Palæontology are not, he thinks, decisive. We can only conclude that the cradle of the undivided Aryans was in the North, because the words for snow and ice are common to all Aryan languages, and because only two, or at most three, seasons of the year were originally distinguished. To this it may be added that the primitive type of the Aryan race was probably that of one of the energetic Northern races.

(3) We have a right to conclude that the primitive Aryan race, at the time of its geographical continuity, extended over a very large region. A semi-nomadic pastoral people, such as the primitive Aryans doubtless were, must have required a vast space to nurture the cattle necessary for their support. A Tartar family in Central Asia

requires three hundred head of cattle, and occupies rather more than two thousand acres. Hence a tribe consisting of 10,000 people would occupy from 4000 to 6000 square miles. The whole of France would support about 50,000 people as pastoral nomads. and the whole pastoral zone of Northern Europe not more than a million. Before the Aryans had emerged out of the hunting into the pastoral stage, the population must have been still more sparse.

That practically the same language, with dialectic differences, might prevail over a vast region occupied by nomad herdsmen, is proved by the case of the Turko-Tartar race, which, at the time of its greatest extension, occupied a region not far inferior in extent to the hypothetical extension of the primitive Aryans, from the Jaxartes to the Atlantic—about 3000 linear miles. In the sixteenth century the Turkic races extended from the mouth of the Lena as far as the Adriatic, and all these tribes were mutually intelligible, speaking merely dialects of the same language. At the present time a Turcoman from Anatolia is able to understand a Yakut from the shores of the Arctic Ocean.

(4) No sharp line of division can be drawn between the European and the Asiatic branches of the Aryan family. Certain races and languages of Europe are more closely connected with those of Asia than the rest. More especially to be noted are the close relations between the Indo-Iranians and the Greeks, as evidenced by the names of weapons, and of words referring to agriculture and religion.

(5) The grade of civilization attained by the undivided Aryans, as exhibited by the conclusions of linguistic palæontology, agrees very closely with that disclosed in the oldest Swiss pile dwellings of the stone age. This would indicate the existence of Aryans in Europe at an early epoch, little if at all later than the linguistic separation.

(6) The movements of the Aryan races, according to the earliest historical notices and traditions, were in a southward and to some extent in an eastward direction. If we may credit early tradition, a portion of Western Asia must have received from Europe its Aryan population of Phrygians and Armenians. This tradition is supported by the near relationship of Armenian to the European languages. On the other hand, no indisputable evidence exists of any migration of Aryans from the East to the West.

Such are the materials, according to Dr. Schrader's investigations, on which the solution of the problem depends. The question as to whether the earliest home of the Aryan race was in Europe or in Asia does not, he thinks, admit of any positive answer. But he concludes by withdrawing the opinion which he had formerly expressed that the Aryans had originated in Asia, and says that he is now unable to conceal his conviction that the European hypothesis—that is, the view that the origin of the Aryan race must be sought in the West rather than in the East—appears to be far more (*weitaus*) in accordance with the facts.

The simultaneous publication in 1883 of Penka's and Schrader's books, one treating the question mainly from the side of anthropology, the other from that of philology, drew renewed attention to the Aryan controversy.

The first result was the abandonment of the Asiatic hypothesis by several scholars, who, like Dr. Schrader himself, had supported it in former years. The first to announce his conversion to the new view was Professor Sayce,* a man honorably distinguished by the fact that he has never hesitated to confess that he has seen reason, on the production of fresh evidence, to change opinions which he had formerly advocated. The European hypothesis has also obtained the published adhesion of Professor Rhys, who has ably expounded the new doctrine in the *Princeton Review*. On the Continent it has been espoused by Tomaschek, who declares for Eastern Europe; by Von Löher, who prefers Germany; by Wilsce, who in the main follows Penka; and by Frederich Müller, who agrees with Cuno's selection of Central Europe. Ujfalvy, Hommel, Fessl, Professor Max Müller, and two American writers, Messrs. Hole and Morris, still advocate various forms of the Asiatic hypothesis.

Professor Max Müller, the only surviving scholar of the old school, has recently given a final pronouncement on the subject. He thus writes in 1887:† "If an answer must be given as to the place where our Aryan ancestors dwelt before their separation . . . I should still say, as I said forty years ago, 'Somewhere in Asia,' and no more." At all events, "somewhere in Asia" is more vague, and therefore more probable than Bactria, which was his earlier and more definite selection. But though he says that he retains his old opinion, he does not appear to have made any new additions to his old argument, which was merely Grimm's theory of the "irresistible impulse," and Pott's assumption that migration has always followed the sun's course, westward from the East.

* In *The Academy*, December 8th, 1883; and in his *Introduction to the Science of Language*, third edition, 1885.

† *Good Words*, August 1887, reprinted in "Biographies of Words."

CHAPTER II.

THE PREHISTORIC RACES OF EUROPE.

1.—*The Neolithic Age.*

THE startling revelations as to the antiquity of man in Europe, which succeeded each other with such rapidity in 1860 and the following years, were, as we have seen, a chief cause of the revulsion of opinion as to the origin of the Aryans. The conclusions of the philologists, which had hitherto been accepted without question, had to be revised in the light of the discoveries of geology, archæology and anthropology. The credit of recognizing the changed conditions of the problem is due to Theodor Benfey, himself a philologist. As early as 1868 Benfey ventured to declare that "since it has been established that from immemorial times Europe has been the abode of man, the whole of the arguments which have been adduced in favor of the migration of the Aryans from Asia fall to the ground."*

These investigations as to the primitive inhabitants of Europe have so materially affected the whole question that it will be needful to devote a chapter to a summary of the results which have been attained.

It is no longer possible to confine the existence of man upon the earth to a period of six thousand years. It has been demonstrated that man was a contemporary of the mammoth and the woolly rhinoceros, and followed the retreating ice sheet which had covered Northern Europe during the last glacial epoch.

From astronomical data Dr. Croll has calculated that in the northern hemisphere the last glacial epoch began some 240,000 years ago, that it lasted with alternations of a milder and even tropical temperature for nearly 160,000 years, and finally terminated about 80,000 years ago. With these calculations Professor Geikie essentially agrees.† He believes that palæolithic man must have occupied parts of Western Europe shortly after the disappearance of the great ice sheet, and that there are reasons for supposing that he was interglacial,‡ like the mammoth and the reindeer, whose remains exist below the till, which was the product of the last extension of the glaciers.§

With this remote period we are not concerned. The flint flakes which constitute the earliest evidences of the existence of man in Europe afford no criteria of language or even of race. Nor can we affirm

* See p. 15, *supra*.
† Geikie, *The Great Ice Age*, p. 114.
‡ *Ibid.*, pp. 552-565.
§ *Ibid.*, p. 160.

that the men by whom they were produced were endowed with articulate speech. The men of the quaternary period, the contemporaries of the mammoth, may or may not have been the ancestors of existing races. But coming down to the later, or neolithic period, when the geological and climatal conditions were essentially the same as they are now, we find that three, if not four, of the existing European types occupied approximately their present seats.

Archæologists have established the chronological sequence of the ages of stone, bronze and iron. These are not necessarily synchronous in different countries. Greece had advanced to the iron age while Italy was still in the bronze period, and the rest of Europe in the age of stone. Bronze was used in the Mediterranean lands long before it reached the shores of the Baltic ; and the Guanches were still in the stone age when, in the fifteenth century, the Canary Islands were rediscovered by the Spaniards.

The iron and bronze ages may be excluded from the present inquiry. We need only concern ourselves with the period of polished stone implements, since it has been proved that the ethnology of Europe is now essentially the same as it was before bronze had superseded stone. Bronze weapons were not introduced, as was formerly supposed, by any new conquering race. Their use gradually spread by the peaceful processes of commerce, and largely through the enterprise of Phœnician traders. The pile dwellings of Central Europe, beginning in the stone age, extend over the whole of the bronze age to the age of iron, and prove that in these regions there were no displacements of population by conquest or immigration, but that the same race, inhabiting the same sites, gradually abandoned stone weapons for weapons of bronze, and bronze swords for swords of iron. The same conclusion is established elsewhere by the fact that the oldest types of copper or bronze implements are modeled on the patterns of the earlier implements of stone or bone.

The age of stone has been divided into two epochs—the palæolithic period, or age of chipped flints, and the neolithic period, when the implements were ground or polished. In the palæolithic period man was the contemporary of the cave bear, the mammoth, the woolly rhinoceros, and other extinct carnivora and pachyderms. The climate was severe, the distribution of land and water was different from that which now prevails, pottery, even of the rudest type, was unknown, the people were nomad hunters, living in caves or rock shelters: whereas in the neolithic period the distribution of land and water was essentially the same as it is now, caves were used for burial rather than for habitation, animals had been domesticated, pottery was fabricated, and the European fauna differed little from that which is found at the commencement of the historic period.

Some anthropologists have asserted that Europe was inhabited by the ancestors of existing races in the palæolithic period. With their arguments we need not concern ourselves, since philologists will probably admit that within the limits of the neolithic age it would be possible to find sufficient time for the evolution and differentiation of the Aryan languages. If it can be shown that the races who inhabited Europe at the beginning of the neolithic period were the ancestors of the races who now inhabit the same regions, we may leave undetermined the question whether they originated in Europe, or whether they emigrated from Asia or from Africa.

It is possible that the palæolithic period may have begun, as M. de Mortillet believes, in the quarternary period of the geologists, some 240,000 years ago; but the neolithic period is comparatively recent. Even M. de Mortillet does not claim for its commencement an antiquity of more than from 10,000 to 20,000 years.

The calculations on which these estimates are based can only be regarded as affording rough approximations to the truth, and they must be taken only for what they are worth.

Some of the best of these natural chronometers are found in Switzerland. But even the earliest Swiss lake dwellings exhibit a state of civilization considerably more advanced than the civilization which linguistic palæontology demands for the primitive Aryans. Consequently we obtain from them only a minimum and not a maximum limit of time for Aryan settlement.

At Pont de la Thièle, between the Lakes of Bienne and and Neufchâtel, there is a pile dwelling of neolithic age which is now 3,000 feet inland from the present shore of the lake. A calculation made by Professor Gilliéron of the rate at which the lake is being filled up with sediment would give for the foundation of this settlement a minimum antiquity of 6,750 years, or about 4,900 B. C.* At this time, therefore, the neolithic people had abandoned the nomad life of the undivided Aryans, and had acquired the skill requisite to build their habitations on piles driven into the bed of the lake; but how much earlier the neolithic period may have begun we have no means of ascertaining.

At the neighboring settlement of Chamblon, on the Lake of Neufchâtel, there is a later pile dwelling, founded towards the close of the neolithic period. A calculation of the rate at which the lake is being filled up with sediment shows that this settlement must have begun before 1,500 B. C.†

M. Morlot considers that the age of the oldest neolithic lake dwellings in Switzerland may be from 6,000 to 7,000 years. Dr. Keller thinks this is too much, and prefers 3,000 to 4,000 years as a safer

* See Keller, *Lake Dwellings*, p. 462; Lyell, *Antiquity of Man*, p. 29; Lubbock, *Prehistoric Times*, p. 401; De Mortillet, *Le Préhistorique*, p. 621.

† G. de Mortillet, *Le Préhistorique*, p. 618.

estimate.* But these structures belong to a comparatively late part of the neolithic period. Some of the pile dwellings in Southern Germany belong to an earlier period in which there were no domestic animals, and when even the rudiments af agriculture were unknown.

From the growth of the cone of the delta of the Tinière, a small stream which falls into the Lake of Geneva near Chillon, a calculation has been made by M. Morlot, which, making every probable deduction, would show that about 6,400 years ago Switzerland was inhabited by people who used implements of polished stone, while for the stratum in which bronze implements were found we have a probable antiquity of about 3,800 years. Hence in Switzerland the epoch of bronze must almost certainly be as old as 1,000 B. C., and may possibly be older by another thousand years.

This estimate agrees essentially with that obtained from the pile dwellings in the valley of the Po, which began in the neolithic age, but, as Helbig has shown,† had reached the bronze age when they were destroyed by the invasion of the Etruscans, which must have been earlier—how much earlier we do not know—than the middle of the eleventh century B.C. The bronze period must therefore have commenced considerably before this date.

The burnt city at Hissarlik, and the tombs at Mycenæ, excavated by Dr. Schliemann, also belong to the age of bronze. They are generally assigned to the twelfth or thirteenth century B.C.

Localities which were further removed from the influences of Semitic civilization were more backward, and hence the foregoing calculations are not irreconcilable with those of M. Arcelin, who from the rate of deposition of the alluvium of the Saône has come to the conclusion that as late as 1,150 B.C. stone implements were still exclusively used in Central Gaul, and that about 400 B.C. bronze had not yet been replaced by iron.

The Victoria Cave, near Settle, in Yorkshire, was inhabited by neolithic people who had made considerable advances in civilization, having apparently domesticated the ox, and possibly the horse. From the accumulation of *débris*, due to the slow weathering of the limestone rock, Professor Boyd Dawkins has calculated that the neolithic occupation of this cave ceased between 4,800 and 5,000 years ago, or before 3,000 B.C.‡

The stone implements found in the kitchen middens or shell mounds of Denmark are more archaic in character than those from the Swiss lake dwellings; indeed, they are considered by some authorities to be mesolithic, forming a transition between the palæolithic and neolithic periods. The people had not yet reached the agricultural or even the

* Keller, *Lake Dwellings*, pp. 526-528.

† Helbig, *Die Italiker in der Poebene*, p. 100.

‡ Dawkins, *Cave Hunting*, p. 115.

pastoral stage—they were solely fishermen and hunters, the only domesticated animal they possessed being the dog, whereas even in the oldest of the Swiss lake dwellings the people, though still subsisting largely on the products of the chase, had domesticated the ox, if not also the sheep and the goat. The shell mounds belong, therefore, to a very early stage of the neolithic period, the civilization which they disclose being ruder than that of the undivided Aryans.

The accumulation of these mounds must have occupied an enormous period. They are very numerous, and some of them are more than 900 feet long, and from 100 to 200 feet broad. They are usually from three to five feet, but occasionally as much as ten feet, in thickness. They are composed of the shells of oysters and mussels, of the bones of animals and fish, with occasional fragments of rude pottery, and numerous implements of flint or bone, and similar refuse of human habitation.*

The flint tools are so abundant that in an hour and a half two visitors collected from one of the mounds 380 specimens. As the population subsisted solely on fishing and the chase, it must have been extremely sparse, probably as thinly scattered as are the Eskimos and the Fuegians, who are in a similar stage of civilization. If the population was as dense as that of the former territories of the Hudson Bay Company, the neolithic population of Denmark would not have exceeded 1,500 ; if it was as dense as in Patagonia, it must have been under 1,000 ; and, if as sparse as in Australia before the settlement of Europeans, not half as much.†

Making every allowance, it is manifest that such enormous heaps of refuse, and such a vast quantity of implements could only have been accumulated during long periods of time, many centuries at least, more probably several millenniums.

But the time when the kitchen midden period came to a close must be itself remote, as is proved by the alteration of the coast-line and by the change of climatic conditions which have taken place.

Some of these mounds are now at a considerable distance from the sea, which can only be due to the slow secular elevation of the land, which is still in progress at the rate of a few inches in a century. In other places the mounds are wanting, evidently owing to the encroachment of the sea.

We have in Denmark three successive periods of vegetation—first, the age of fir ; second, the age of oak ; and, third, the age of beech. In the Roman period the country was covered, as it now is, by vast forests of beech, the fir and the oak having then disappeared. These changes in the vegetation are attributed to slow secular changes of climate. Now the stone age agrees mainly with that of the fir, and partly with that of the oak ; the bronze age agrees mainly with the

* Lubbock, *Prehistoric Times*, pp. 230-233. † *Ibid.*, pp. 607, 608.

period of the oak, and the iron age with that of the beech. The shell mounds, which belong to the early neolithic period, are proved to belong to the age of the fir, since the bones of the capercailzie, a bird which feeds on the young shoots of the fir, have been found in the kitchen middens, while stone implements of the kitchen midden type have been discovered in the peat bogs among the stumps of the firs. Taking these considerations into account, Professor Steenstrup, the highest authority on the subject, is of opinion that a period of from 10,000 to 12,000 years must be allowed for the accumulation of the vast mounds of refuse and for the successive changes of the forest trees from fir to oak, and from oak to beech, which can only be due to considerable changes of climate—changes, moreover, which had already been effected at the commencement of the iron age.*

Another chronometer is afforded by the peat, in which, at various depths, neolithic implements are buried. Professor Steenstrup has calculated that from 4,000 to 16,000 years would be required for the formation of certain of these peat bogs. The presence of pottery proves that the shell mounds belong to the neolithic age, the commencement of which can hardly therefore be placed later than 10,000 years ago.

2.—*The Methods of Anthropology.*

Broca has laid down the axiom that the ethnic characteristics of the first order of importance are not linguistic but physical. As to the nature of the speech of the neolithic peoples of Europe we have inferences rather than any positive facts to guide us. As to their physical characteristics the evidence is abundant and conclusive. This evidence consists partly of the statements of Greek and Roman writers, but is derived mainly from the measurements of skulls. The shape of the skull is one of the least variable characteristics of race, so much so that the skulls from prehistoric tombs make it possible to prove that the neolithic inhabitants of Europe were the direct ancestors of the existing races. The skull form is expressed by the numerical ratios of certain measurements which are called indexes. Of these the most important are the latitudinal, or, as it is commonly called, the cephalic index, which gives the proportion of the extreme breadth to the extreme length of the cranium; the altitudinal or vertical index, which gives the proportion of the height of the skull to the length; the orbital index, which gives the proportion of the height of the eye orbit to the breadth; the facial angle; the nasal index; and the index of prognathism, by which we estimate the shape of the face. These indexes, taken in conjunction with the shape of certain bones, especially the femur and the tibia, enable us to determine with con-

* Penka, *Herkunft der Arier*, p. 62.

siderable certainty, the ethnic relationship of prehistoric to existing races.

The latitudinal or "cephalic" index is thus determined: Divide the extreme breadth of the skull by the length from front to back, and multiply by 100. Thus, if the breadth is three-fourths of the length, the index is said to be 75. Cephalic indexes vary from 58 to 98.

The term dolicho-cephalic, or long-headed, is applied to skulls with low indexes; brachy-cephalic, or broad-headed, to those with high indexes; and ortho-cephalic, or meso-cephalic, to the intermediate class. The black races are dolicho-cephalic, the white races incline to ortho-cephalism, and the yellow races to brachy-cephalism. Anthropologists are not entirely agreed as to the precise limits of index to which these terms should be restricted, but we shall not be far wrong if we call skulls with indexes below 75 dolicho-cephalic, from 75 to 78 sub-dolicho-cephalic, from 78 to 80 ortho-cephalic, below 83 sub-brachy-cephalic, and of 83 and over brachy-cephalic. The Swedes are the most dolicho-cephalic race in Europe, the Lapps the most brachy-cephalic, the English the most ortho-cephalic. North Germany is sub-dolicho-cephalic, South Germany, sub-brachy-cephalic.

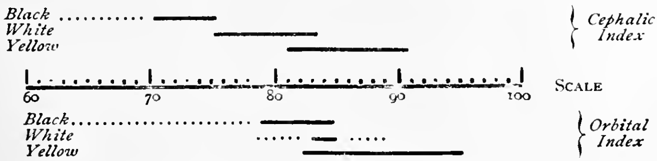
The orbital index, which gives the proportion of the height to the breadth of the orbit is believed by Broca to be of especial value as a test of race, since it is not liable to be affected by causes connected with the struggle for existence. Among the black races it is lowest, varying, in Africa, from 79.3 to 85.4, and descending to 61 among the Tasmanians; among the yellow races it is high, varying from 82.2 to 95.4; among the Europeans it is usually between 83 and 85. A similar test applies to the section of the hair. In the Mongolian or yellow race it is circular; in the black or African race it is flat or ribbon-shaped; in the white or European race it is oval. The hair of the Mongolian is straight, that of the African frizzled or woolly, that of the European is inclined to curl.

All these tests agree in exhibiting two extreme types—the African, with long heads, long orbits, and flat hair; and the Mongolian, with round heads, round orbits, and round hair. The European type is intermediate—the head, the orbit, and the hair are oval. In the east of Europe we find an approximation to the Asiatic type; in the South of Europe to the African. The neolithic tombs of Europe exhibit notable approximations both to the African and to the Asiatic types.

The position of the European races between the African and the Asiatic may be exhibited graphically by the diagram on the following page.

Where, it has been asked, did the human race originate? Darwin inclines to Africa, De Quatrefages to Asia, Wagner to Europe in the miocene epoch, when the climate was sub-tropical. If it originated in

Europe we may suppose it was differentiated into the extreme Asiatic and African types; or, on the other hand, Europe may have been the place where the African and Asiatic types met and mingled. Those who hold the former view may believe with Penka that the Aryans



represent the oldest European race; those who hold the latter opinion may maintain that while Aryan speech came originally from Asia it was subsequently acquired by men who were largely of African race.

3.—*The Races of Britain.*

In Cæsar's time there were in Gaul three races—the Aquitanians, the Celts, and the Belgæ; as well as a fourth race, the Germans, eastward of the Rhine. In the neolithic tombs of Europe the remains of these four races can be traced, and from them alone the Aryan-speaking peoples of Europe have descended. But it is evident that only one of these four races can represent the primitive Aryans, the others being merely Aryan in speech, but non-Aryan by descent.

On the Continent there were no insurmountable physical obstacles to impede the immigration of intrusive races; but in Britain the "silver streak" has rendered the ethnological problem less complicated. At the beginning of the bronze age we discover in British tombs the remains of two out of the four races of the Continent. One of these arrived towards the close of the neolithic age, before which time Britain seems to have been inhabited by one race only, which may possibly have descended from the people of palæolithic times, and who may even have migrated from the Continent with the great pachyderms before the formation of the channel.

The older race was of feeble build, short stature, dark complexion, and dolichocephalic skull. They buried their dead in caves, and when caves were no longer available, in long barrows provided with interior chambers and passages. Some of these long barrows are 400 feet in length and fifty feet in breadth, and resemble artificial caves—imitations or survivals, as it were, of the earlier sepulchral caverns. The long barrows are plainly of later date than the cave sepulchres. Thus in a sepulchral cave at Cefn, near St. Asaph, the skulls are of precisely the same type as those in a long barrow at the same place, but their relative antiquity is shown by the fact that the remains of wild animals are rare in the barrow but common in the cave. Plainly the people had reached the pastoral stage when the cave was abandoned for the barrow.* The long barrows all belong to the stone age. Canon Greenwell asserts that "no trace of metal has been found . . in any undisturbed part of a long barrow," while "pottery of any kind is very unfrequent."† In barrows of this description, from Caithness to Wiltshire, the skulls are all of one type, and archæologists are agreed that in the long barrow period Britain was inhabited by one race only.

This race is identified by ethnologists with the British tribe of the Silures, who at the time of the Roman Conquest inhabited the counties of Hereford, Radnor, Brecon, Monmouth, and Glamorgan. From their physical characteristics Tacitus concluded that they belonged to the Iberian race. His words are, "Silurum colorati vultus torti plerumque crines, et posita contra Hispania, Iberos veteres trajecisse, easque sedes occupasse, fidem faciunt."‡

No importance must be attached to the conjecture that the Silures had emigrated from Spain. It was a guess, based on a valuable observation as to the physical resemblance of this swarthy British tribe to the Iberians.

Modern ethnologists have made the same observation, and have more especially noted the resemblance of the Spanish Basques to the small dark Welshmen of Denbighshire. The same type is found in some of the Hebrides, especially in Barra. It is found in Kerry, and also west of the Shannon, in Donegal and Galway, notably in the Isle of Aran in Galway Bay, where in an old graveyard Dr. Beddoe found four dolichocephalic skulls, with a mean index 74,25, the lowest in the British Isles.§ Dr. Beddoe also found an approach to this index in the region occupied by the Silures, five skulls from Micheldean giving a mean index of 74.8. In a more or less modified form this type prevails throughout the Silurian region of Wales and the west of England, where we find an oval-featured race, of short stature and feeble muscular development, with dolichocephalic skull, dark hair, and black eyes.‖

The Continental extension of this type will be discussed hereafter.¶ Suffice it to say that skulls resembling those of the British long barrows have been found in sepulchral caves in Belgium, France, Spain, Algeria and Teneriffe. It is believed that descendants of this race may be recognised among the Basques, the Corsicans, the Berbers and the Guanches of the Canary Islands.

* Dawkins, *Cave Hunting*, pp. 164, 165.

† Greenwell, *British Barrows*, pp. 543, 508.

‡ Tacitus, *Agricola*, c. 11.

§ Beddoe, *Races of Britain*, p. 227.

‖ Greenwell, *British Barrows*, p. 630; Elton, *Origins of English History*, pp. 137, 141; Dawkins, *Early Man in Britain*, p. 330; Penka, *Origines Ariacæ*, p. 90.

¶ See p. 54, *infra*.

For this short, dark dolichocephalic type we may adopt the usual and convenient name "Iberian." Professor Rolleston prefers the term "Silurian," and it has been variously designated by other writers as the Euskarian, Basque, Berber or Mediterranean race. By some French writers it is called the "Cro-Magnon" type, from a skull, possibly of palæolithic age, found in a sepulchral cavern at Cro-Magnon in Périgord.

Towards the close of the neolithic age, or possibly at the beginning of the bronze age, the southern and eastern portions of Britain were invaded and occupied by a wholly different race—tall, muscular, brachycephalic, and almost certainly with xanthous or rufous hair and florid complexion. They are known as the people who buried in round barrows, and to them in all probability we may ascribe the erection of Avebury and Stonehenge,* and also the first introduction into Britain of Aryan speech and of implements of bronze. This race Dr. Thurnam identifies with the Celts, and he calls the type the "Turanian" type, believing it to be an offshoot, through the Belgic Gauls, from the great brachycephalic stock of Central and North-Eastern Europe and Asia. It is also the prevailing type among the Slavonic races. This "Turanian" type of Dr. Thurnam is the "type Mongoloide" of Prüner-Bey. By Professor Rolleston it is called the "Cimbric" type, on the ground that it resembles that of the broad-headed neolithic people of Denmark, the old Cimbric Chersonese. Dr. Thurnam identifies the round barrow people of Britain with the broad-headed neolithic race of Belgium and North-Eastern France, who undoubtedly spoke a Celtic language, and who are designated by Broca as the Kymry, to distinguish them from the short, dark brachycephalic race of Central France, to whom he maintains the name Celts properly belongs. But as there can be little doubt that the people of the round barrows introduced into Britain what is usually called "Celtic" speech, it will be convenient, though perhaps incorrect, to designate the people of the round barrows as the Celtic race.

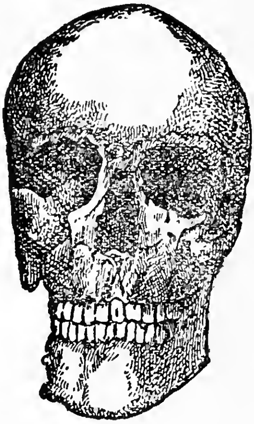
The interments of these two races, the "Iberians" of the long barrows and the "Celts" of the round barrows, can be readily distinguished. The skulls, as Canon Greenwell observes, are "as markedly different as any two series of crania can be."† The difference is well exhibited in the skulls on next page, both from the wolds of the East Riding of Yorkshire, and here reproduced by Canon Greenwell's kind permission. The first is the skull of a middle-aged man of the "Iberian" race, found at Rudstone,‡ in a long barrow, 210 feet long, and varying in breadth from 75 to 45 feet. It is of a pronounced dolichocephalic type, the index being as low as 72. The second is the skull of a man also in the middle period of life, of the other, or "Celtic"

* Elton, *Origins*, p. 146.

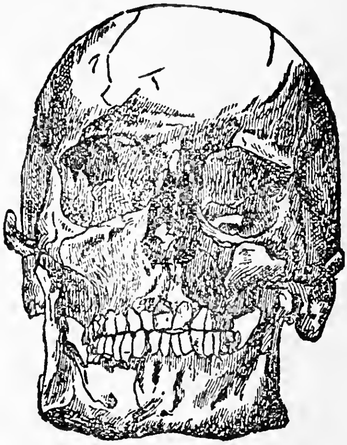
† Greenwell, *British Barrows*, p. 482.

‡ Greenwell, *British Barrows*, pp. 501, 613.

race, which was found in a round barrow, 70 feet in diameter, in the neighboring parish of Cowlam.* This skull is decisively brachycephalic, the index being as high as 84. Flint implements accompanied both of these interments, but no articles of metal.

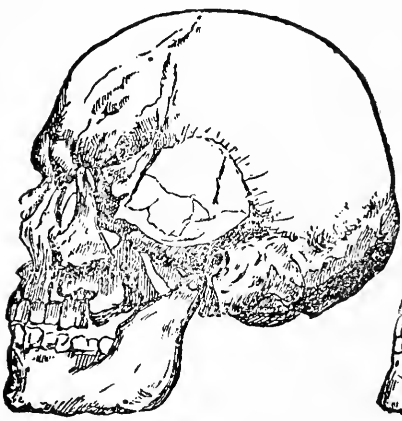


LONG BARROW SKULL (MALE), FROM RUDSTONE, E. R.

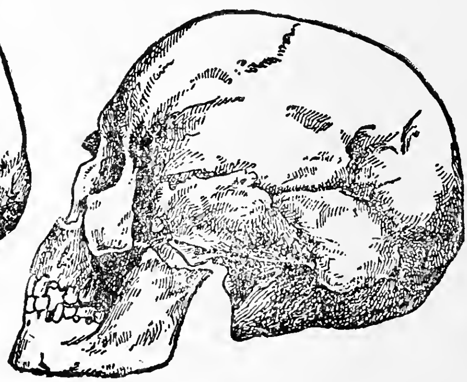


ROUND BARROW SKULL (MALE), FROM COWLAM, E. R.

The two races are distinguished not only by the difference in the shape of the skull, but by the whole character of the face. In the



COWLAM SKULL (SIDE VIEW).



RUDSTONE SKULL (SIDE VIEW).

Celtic skull, of which that from Cowlam is a favorable specimen, the head is massive and powerful, the face angular and prognathous, with a projecting mouth and powerful square jaws. The broad capacious

* *Ibid.*, pp. 226, 587.

forehead and the short, square chin indicate mental power and determination of character. The cheek bones are high and broad, the orbits of the eyes nearly circular, with supraciliary ridges well developed, which must have given a fierce and beetling aspect to the face. The nose must have projected forwards, and the sockets of the front teeth are oblique. The skulls of this race are usually distinguished by their capacity and vertical height, which is actually greater than the breadth.*

To this type the skulls of the Iberian race present the greatest possible contrast. The face is oval, feeble, and orthognathous; the forehead narrow; the chin weak, pointed and elongated. The nose is usually not so broad as in the other race, but longer by a quarter of an inch, the space between the nostrils and the mouth considerable, giving a weak upper lip, and the sockets of the front teeth are vertical. Neither the cheek bones nor the supraciliary ridges are developed, and the orbits of the eyes are somewhat elongated. The aspect of the face must have been mild and gentle. The vertical views of these two skulls show that the greater length of the one, and the greater breadth of the other, are mainly due to occipital developments. The difference in the skulls extends also to the other bones of the skeleton. The Iberian race was short, with slender bones and feeble muscular attachments, while the Celtic race was tall, powerful and muscular.

In both races the distinctive characters are less highly accentuated in the skulls of the women, as will be seen from the representations of two female skulls from the Yorkshire wolds—one a long skull of the Iberian type, orthognathous, with an index of 68, from a barrow on Sherburn wold;† the other a broad skull of the Celtic type from a neighboring barrow at Flixton,‡ strongly prognathous, and with an index of 82.

From ninety-five round barrow skulls we obtain a mean cephalic index of 81, and a mean altitudinal index of 77; while sixty-seven long barrow skulls give a mean cephalic index of 71.25, and a mean altitudinal index of 73.

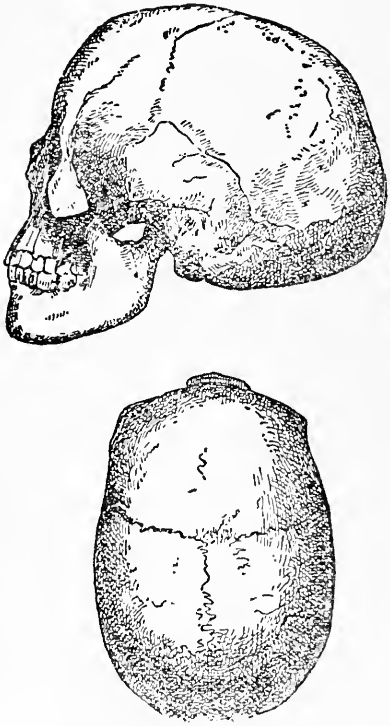
The difference of stature between the two races is considerable. In the Iberian race the average height for both sexes was 5 feet 4½ inches (or 5 feet 5½ inches for the men), the tallest of the men measuring 5 feet 6 inches, and the shortest of the women 4 feet 8 inches. In the Celtic race the height, calculated from the length of the thigh bones, ordinarily varied from 5 feet 7 inches to 5 feet 9 inches, the average height being 5 feet 8½ inches.

The stature of the Celts struck the Romans with astonishment. Cæsar speaks of their *mirifica corpora*, and contrasts the short stature

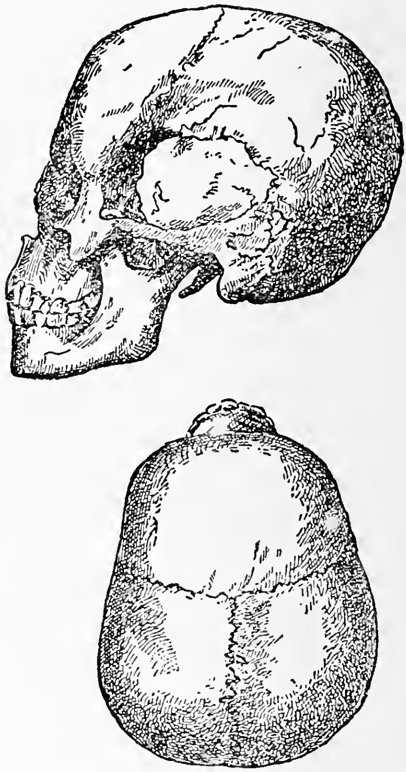
* Greenwell, *British Barrows*, p. 645.

† Greenwell, *British Barrows*, p. 608. ‡ *Ibid.*, p. 575.

of the Romans with the *magnitudo corporum* of the Gauls. Strabo also, speaking of the Coritavi, a British tribe in Lincolnshire, after mentioning their yellow hair, says, "to show how tall they are, I saw myself some of their young men at Rome, and they were taller by six inches than any one else in the city."* This might seem an exagger-



LONG BARROW SKULL (FEMALE), FROM SHERBURN WOLD, E. R.



ROUND BARROW SKULL (FEMALE), FROM FLIXTON WOLD, E. R.

ation, but is borne out by the bones found in some round barrows. For instance, at Gristhorpe, in the East Riding, a round barrow was opened containing the skeleton of a man whose stature must have been 6 feet 2 inches.

There can be little doubt that the Iberian race was dark in complexion, with black hair and eyes. As to the Celtic race, it is almost certain that they were fair, with red or yellow hair, and blue or blue-gray eyes. The most conclusive statement comes from Dio Cassius, who has left us a description of Boadicea, who almost certainly belonged to this race. He describes her as of great bodily proportions, ἦν δὲ καὶ τὸ σῶμα μεγίστη. The fierceness of her appearance struck

* Elton, *Origins*, p. 240.

beholders with awe, and the expression of her countenance was exceedingly severe and piercing. Her voice was harsh, and she had a profusion of tawny hair, τήν τε κόμην πλείστην τε καὶ ξανθοτάτην, which reached down to her hips. The word ξανθός is used for various tawny shades of color, either golden, or auburn, or with a tinge of red.

We have other testimonies to the same effect. Lucan says the Britons were *flavi;* Silius Italicus describes their hair as golden ; and Vitruvius, referring seemingly to the same race, speaks of their huge limbs, their gray eyes, and their long, straight, red hair.

The Coritavi, the Celtic tribe which occupied part of Lincolnshire and the valley of the Trent, are described by Strabo as having yellow hair, but not so yellow as that of the Gauls ; and Tacitus mentions the red hair and huge limbs—*rutilæ comæ et magni artus*—of the Caledonians, who, in this respect, he compares with the Germans.

The Belgic Gauls, who, as we shall presently see, were probably of the same race as the round barrow people of Britain, are uniformly described by ancient writers as tall, large-limbed, and with red or yellow hair. Pösche, Diefenbach, and De Belloguet have collected numerous testimonies to this effect.* Thus, according to Diodorus Siculus, the Galatians were xanthous, ταῖς δὲ κόμαις . . . ξανθόι. Livy describes the *promissæ et rutilatæ comæ* of the Gauls. Claudian says, *flava repexo Gallia crine ferox.* Ammianus Marcellinus describes the great stature, the white skin, and the red hair of the Gauls. Silius Italicus speaks of the huge limbs and golden locks of the Boii ; and Strabo says the Germans resembled the Gauls, but were taller, more savage, and more xanthous. Manilius, speaking of the tall Germans with their yellow hair, says that the Gauls were not so red.

The old Celtic type, tall, powerful, red-haired, with a florid complexion, and inclined to freckle, may be recognized in some of the Scotch clans, such as the MacGregors and the Camerons, who are altogether different from the Frasers, or the dark clans of the Western Isles.

In Ireland there were the same two races, which are graphically described by McFirbis in his *Book of Genealogies.* One race, which he calls the Fir-Bolg, had dark hair and eyes, small stature, and slender limbs, and constituted the despised servile class of the Irish people. They belong, says Mr. Skene, "to the same class with the Silures, and may be held to represent the Iberian race which preceded the Celtic." The other race, called the Tuatha Dè Danann by McFirbis, was tall, with golden or red hair, fair skin, and blue or blue-gray eyes. They "correspond in character with Tacitus' large-limbed and red-haired Caledonians."†

* Pösche, *Die Arier*, p. 25 ; Diefenbach, *Origines Europææ*, p. 161 ; De Belloguet, *Ethnogenie Gauloise*, ii., pp. 63, *seq.*

† Skene, *Celtic Scotland*, vol. i., p. 178 ; cf. Elton, *Origins*, p. 159.

As to the relative priority of the Iberian and Celtic races in Britain there can be no question. The Iberians were plainly the primitive inhabitants of the Island, and the Celts were later invaders, who were not only a more powerful race, but possessed a higher civilization. This is indicated by the form of the barrows in which they buried. The abodes of the dead represent the abodes of the living. The Iberians must at one time have been troglodytes, as the long barrow is plainly a survival of the cave. The Celts must have lived in huts or pit dwellings, on the model of which the round barrows are constructed. In the long barrows metal is absent and pottery is rare, while the presence of pottery is a distinctive feature of the round barrows,* and bronze is not unknown.

As bronze has been found in round barrows, it is frequently asserted that the Celts were armed with bronze weapons when they invaded Britain. This conclusion is not borne out by the evidence, which indicates that the Celts arrived in the neolithic period, and obtained bronze by commerce from Gaul at a later time. Canon Greenwell tabulates 485 interments in round barrows; in 201 cases these were associated with pottery, in 150 cases with implements of stone, bone, or horn, and in only twenty-three with bronze. Of these twenty-three cases only five were primary interments, fifteen were secondary interments, and the rest doubtful.

Mr. Mortimer, who has opened 241 round barrows in the East Riding, containing 629 bodies, found pottery in 203 cases, stone implements in 150, and bronze in twenty-six. These facts make it probable that when the round barrows were first erected bronze was either unknown or extremely rare, but that it had to some extent come into use when secondary interments took place in barrows which had been raised at an earlier period.

Moreover, no brachycephalic skull has been found in any primary interment in a long barrow, though they occur in secondary or later interments; while in the round barrows the skulls are usually brachycephalic, though dolichocephalic skulls are occasionally found in them, especially on the Yorkshire wolds.†

From these facts we may confidently draw the conclusion that during the greater part of the neolithic age Britain was inhabited solely by a short, dark, dolichocephalic race, originally troglodytes, and that towards the conclusion of the stone age it was invaded by a tall, fair, brachycephalic, hut-building race, which either brought with them, or before long acquired, implements of metal.

We may also accept Dr. Thurnam's conclusion that the older dolichocephalic race was pre-Aryan, belonging to the same stock as the Spanish Basques, and that the later brachycephalic invaders spoke an Aryan language, which there can be little doubt was Celtic.

* Greenwell, *British Barrows*, pp. 508, 458-478. † *Ibid.*, pp. 543, 549.

If these conclusions, now very generally accepted, can be maintained, we have reached a fixed point in the discussion as to who the Aryans were. The first Aryan-speaking race which appeared in Britain was brachycephalic, tall, and red-haired, of the type characterized by Professor Rolleston as "Turanian," and by Prüner-Bey as "Mongoloide."

It is not improbable, as Professor Rhys has suggested, that there may have been two successive Celtic invasions of Britain. The first, he thinks, was that of the Goidels, who spread to Ireland and Scotland, amalgamating with the Iberian aborigines, and imposing on them their language. The second invasion was that of the Brittones, who seized the more fertile portions of the island, driving the Goidels before them to the West and North.* This theory helps to explain some linguistic facts, and is not without support from craniological indications.

The mean index of Dr. Thurnam's long barrow skulls is, as we have seen, 71 25, and that of the round barrow skulls of Yorkshire 81 But in North Wales, and in Professor Huxley's skulls from the tumulus at Keiss in Caithness—districts where we might expect to find an amalgamation of the two races—the mean index is 75.5, which may represent the mixed "Goidelic" type of Professor Rhys.

4.—*The Celts.*

We have now to trace the two neolithic British races on the Continent—the Celtic type eastward to the confines of Asia; the Iberian type southward through France and Spain to Northern Africa.

The Celts appear to have crossed to Britain from Belgic Gaul. In the neolithic age a race indistinguishable from that of the British round barrows occupied Belgium. A sepulchral cave at Sclaigneaux, fourteen miles from Namur, contained numerous skeletons of the round barrow type, with indexes of 81.1 and 81.6. Implements of bone and flint, of late neolithic forms, were found, but no bronze. Bones of the dog, the ox, and the goat indicate that these people had reached the pastoral stage.†

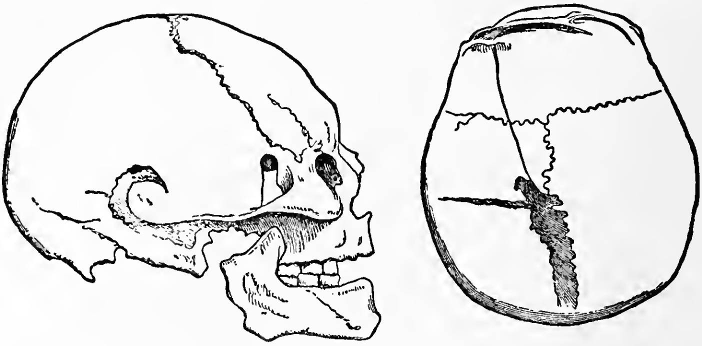
The skull figured on the next page resembles some of the ruder skulls from the British round barrows.

In the early neolithic age the southern frontier of the Belgic Gauls seems to have been the line of the Meuse. They held the modern province of Hainault; while another race, as will presently be shown, occupied the province of Namur.‡ At a later time they advanced southward, imposing their Celtic speech on the earlier races of Central France. In the artificial sepulchral grottoes on the Marne and

* Rhys, *Celtic Britain*, p. 213. † Dawkins, *Cave Hunting*, pp. 219, 199.
‡ See p. 69, *infra*.

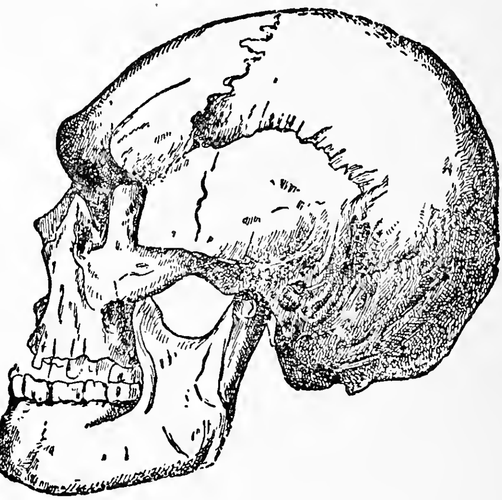
the Oise skulls of this race are found, together with those of the earlier population.

This race may also be traced eastward to Denmark. Dr. Rolleston observes that "the bronze period Briton very closely resembles in his



SKULL FROM SCLAIGNEAUX, BELGIUM.

osteological remains the brachycephalous Dane of the neolithic period; and the likeness between these and some of the modern Danes has been noticed by Virchow." * From a neolithic tumulus at Borreby, in the Danish island of Falster, four skulls of the round barrow type



MALE SKULL FROM BORREBY, DENMARK.

were obtained, whose indexes were 80, 81, 82, and 83. One of these Borreby skulls is figured below,† and bears a striking similarity to the ruder skulls from the British round barrows.

This resemblance will be seen by superimposing the outline of the

* Greenwell, *British Barrows*, p. 680.

† Hamy, *Précis de Paléontologie Humaine*, p. 368.

Borreby skull on that of a Celtic skull from Ilderton in Northumberland,* the index of which is 82.

In Denmark this brachycephalic type has been singularly persistent. To judge by the skulls of Flambard, and other Danish ecclesiastics buried at Durham, the Danes 800 years ago were brachycephalic. According to Dr. Beddoe the modern Danes are of the same type as

—— BORREBY.
.... ILDERTON.
SKULLS FROM BORREBY AND FROM ILDERTON, NORTHUMBERLAND, SUPERIMPOSED.

the round barrow people. The mean cephalic index of the Danes is 80.5, and their average height nearly 5 feet 7 inches; the mean index of the round barrow people being 81, and their mean stature 5 feet 8 1-2 inches. The hair of the Danes, according to Dr. Beddoe, is either pale yellow or light brown, and their eyes are almost invariably light in color, usually either blue or bluish-gray. Some of the Danes, however, seem to have been dark. Dr. Beddoe found a black-haired race in the island of Moen, where brachycephalic skulls have been found in ancient graves. These black-haired Danes may be the Dubhgaill, or "black strangers," who are contrasted by Irish chroniclers, who describe the Viking inroads, with the Finngaill, or "fair strangers," who are supposed to have been Norwegians.† Possibly we may thus account for the tall, dark brachycephalic people who are met with in some of the Danish districts in England.

At the beginning of the historic period the valleys of the Main and the Upper Danube were occupied by Celtic tribes. In this region Celtic names abound. The Boii, a Celtic people, gave their name to Bavaria (Boio-varia), and to Bohemia (Boio-hemum).

The ethnic frontier between Celts and Teutons was the continuous mountain barrier formed by the Teutoberger Wald, the Thuringer Wald, and the Riesen Gebirge. North of this line the population is now dolichocephalic, the index in the neighborhood of Hanover, for instance, being 76.7, and at Jena 76.9, while to the south of this line the people are more brachycephalic, the mean index being 79.2 in

* Greenwell, *British Barrows*, p. 583. † Skene, *Celtic Scotland*, vol. i. p. 304.

Hesse, 79.3 in Swabia, 79.8 in Bavaria, 80 in Lower Franconia, and 80.1 in the Breisgau.*

The people of the modern kingdom of Würtenberg are also brachycephalous. Hölder, the chief authority on the anthropology of Würtenberg, now considers the type to be "Turanian," or "Sarmatian," and not, as he had formerly supposed, "Ligurian."

German ethnologists believe that a Celtic people worked the salt mines in the neighborhood of Halle, a name which, like that of Hallstadt, also a Celtic settlement, is more easily explained from Celtic than from Teutonic speech. The present inhabitants of this district differ from the North German type; they are brachycephalic, with a mean index of 80.5, which is the same as that of the Danes, and differs little from that of the round barrow skulls of Britain, which is 81.

Halle seems to have been the most northern outpost of the Celts in Germany, since beyond the Teutoberger Wald, a few miles to the north of Halle, the type changes, and the mean cephalic index drops from 80.5 to 76.7.

Southern Germany is now Teutonic in speech, the local names and the persistent ethnic type alone bearing witness to the primitive Celtic occupation. We know, however, that in the early centuries of our era Southern Germany was Teutonized in speech by German invaders, whose tombs, known as the Row Graves, contain dolichocephalic skulls with a mean index of 71.3. The older Celtic sepulchres of this region are known as the Grave-Mounds, and contain orthocephalic or brachycephalic skulls with a mean index of 78.8, rising to a maximum of 82.9.

In Würtenberg and Bavaria a number of pile dwellings of the neolithic age have been discovered which seem to be prototypes of those which are so numerous in the Swiss lakes. These people must gradually have spread southwards from Germany, since the older pile dwellings on the Lake of Constance belong to an earlier period than those on the lakes of Neufchâtel and Bienne.

The Swiss craniologists, His and Rütimeyer, attribute the erection of the lake dwellings in Switzerland to "our Celtic ancestors," the Helvetii.† The mean index of eight skulls ‡ found in the pile dwellings is 80.95. The index of the round barrow skulls of Britain is 81. One of these Helvetian skulls, called the "Sion type" in the *Crania Helvetica*, is figured on the next page. It resembles the round barrow skulls, such as those from Cowlam and Gristhorpe, and the Borreby skull from Denmark. § But, as we might expect from the comparatively high civilization attained by the people of the Swiss pile dwell-

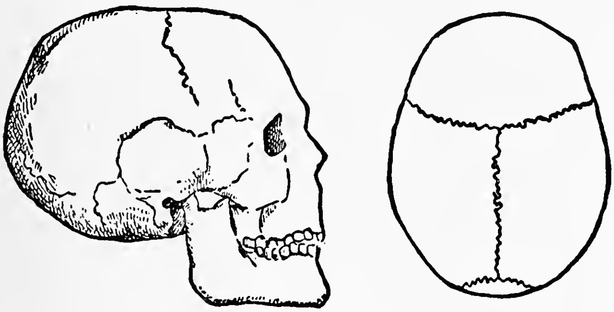
* Peschel, *Völkerkunde*, p. 59. † His and Rütimeyer, *Crania Helvetica*, pp. 34, 35.

‡ The indexes are—Auvernier skulls, 77.2 and 78.5; Nidau, 78 and 78.4; Möringen, 83; Meilen, 83.2; Pfiedwald, 83.8; Robenhausen, 85.5. If Robenhausen be excluded, as possibly Rhætian, the mean index will be reduced to 80.03.

§ See pp. 42, 79, *supra*.

ings, their skulls are somewhat larger, loftier, and better formed than the ruder skulls of the British round barrows.

Towards the close of the neolithic age the same Aryan-speaking race which constructed the Swiss pile dwellings seems to have crossed the Alps, erecting their pile dwellings in the Italian lakes and in the marshes of the valley of the Po. Helbig has proved that these people must be identified with those whom we call the Umbrians.* This conclusion, established solely on archæological grounds, is confirmed by the close connection between Celtic and Italic speech, and also by



HELVETIAN SKULL (SION TYPE).

the almost identical civilization disclosed by the pile dwellings of Italy and those of Switzerland.

Further, the craniologists have proved that while the people of Southern Italy are dolichocephalic, belonging apparently to the Iberian race, they become more and more brachycephalic as we go northward, especially in the district between the Apennines and the Alps. In Venetia, Lombardy, and the Emilia, the region occupied by the Umbrians, Professor Calori has measured 1,106 modern skulls, of which 963, or 87 per cent., were brachycephalic, with indexes above 80. In Lombardy and the Emilia dolichocephalic skulls, with indexes under 74, amounted to less than 1 per cent. In the Neapolitan provinces, on the other hand, 17 per cent. of the skulls had an index below 74, and 64 per cent. below 80.† The mean index of the Umbrian skulls found in a pre-Etruscan cemetery at Bologna is 79.35, and the index of a typical ancient Umbrian skull, which is figured by Professor Calori, is 81.79.

Latin and Umbrian were merely dialects of the same language, but in Rome there was a large admixture of Etruscan and Campanian blood. Skulls of the pure Latin race are rare, owing to the prevalent practice of cremation, while skulls ostensibly Roman often prove on investigation to be those of freedmen or provincials. The best accredited genuine skull of the old Latin race comes from a sarcophagus

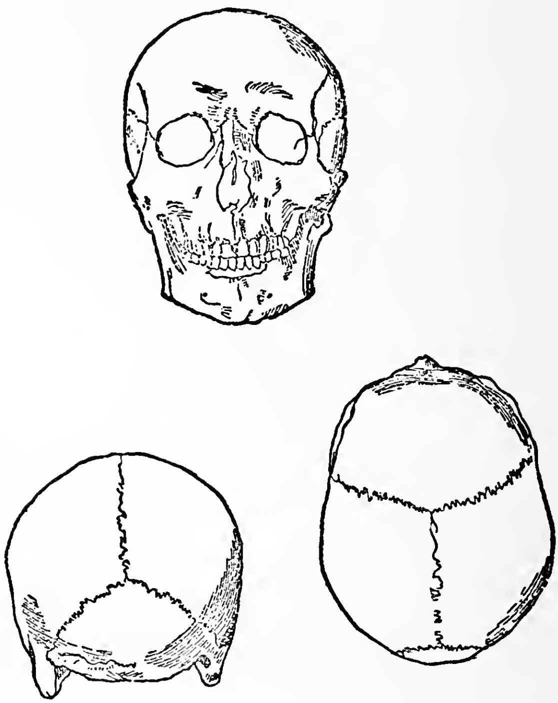
* Helbig, *Die Italiker in der Poebene*, pp. 29-41.

† Peschel, *Völkerkunde*, p. 60.

discovered in the Roman cemetery at York. We learn from the inscription that this sarcophagus contained the body of Theodorianus of Nomentum, a town in Latium. This skull, figured below, is of the brachycephalic Celtic type, the cephalic index being 80.

There is very remarked resemblance in the outlines of the Latin and Helvetian skulls, and those of the better class from the British round barrows. They exhibit no greater differences than the refinement of type due to the progress from neolithic barbarism to the high civilization of Rome.

The oldest Umbrian settlements—such as the pile dwellings in the Lake of Fimon, near Vicenza—prove that the Umbrians, when they arrived in Italy, were in much the same stage of civilization as the undivided Aryans. They lived chiefly by the chase, but had domesti-



SKULL OF THEODORIANUS OF NOMENTUM.

cated the ox and the sheep. Agriculture, even of the rudest description, seems to have been unknown, since no cereals were found ; but there were considerable stores of hazel nuts, of water-chestnuts, and of acorns, some of which had been already roasted for food.*

Before the arrival of the Umbro-Latin race, Italy was inhabited by Iberian and Ligurian tribes. In the neolithic cave at Monte Tignoso,

* Keller, *Lake Dwellings*, vol. i. p. 375.

near Leghorn, two skulls were found—one of them dolichocephalic, with an index of 71, doubtless Iberian; the other highly brachycephalic, with an index of 92, probably Ligurian. Another neolithic cave, the Caverna della Matta, contained an Iberian skull, index 68, and a Ligurian skull, index 84. The Olmo and Isola del Liri skulls, believed to be of palæolithic date, are dolichocephalic.

The round barrow race, which we have now traced from the Tyne to the Tiber, extended eastward down the Danube, and across the great plain of Russia. All the nations of Slavic speech are brachycephalic, and their hair and eyes are mostly light in color.

The Great Russians, who occupy the territory east of a line from the Sea of Azov to the Gulf of Finland, have chestnut hair, brown eyes, and a mean index of 80.2. The White Russians, who occupy the old Lithuanian territory, have flaxen hair, and gray or light blue eyes. Black hair and eyes are only found among the Little Russians, near Kiev, who are probably largely of Tartar race.

The index of the Ruthenians in Galicia is 80.4; of the Slovaks, 81; of the Croats, 82; of the Czechs, 82.1; of the Roumanians, who are to a great extent of Slavic blood, 80; of the Poles, 79.4; of the Serbs, 78.8.*

The same light-haired brachycephalic type prevails also when we pass beyond the frontier of Aryan speech into Finno-Ugric territory.

The Finno-Ugric tribes are all brachycephalic, and most of them have light eyes and fair or rufous hair. Of the Wotiaks 50 per cent. have blue eyes; the rest are gray, green, or brown eyed, black eyes being unknown. In only 2 per cent. the hair is black. It is usually brown or red, and occasionally flaxen. The Zyrianians of the Petschora have also fair hair and blue eyes.† Many of the eastern Finns, especially the Tscheremis, the Tschuvash, the Woguls, and the Ostiaks of the Obi, have red hair, and the eyes are blue, gray, green, or chestnut. The cephalic index varies from 80.4 to 83.7, and the index of their kinsmen, the Magyars, is 82.3. The Tavastian Finns have flaxen hair and blue or gray eyes; the Karelians chestnut hair and grayish-blue eyes. Both races are brachycephalic, the Karelians less so than the Tavastians, the index varying from 81.48 to 83.7. The Esthonians are fair, with yellow or flaxen hair and blue eyes. They are brachycephalic, with a mean index of 80.48.

Vambéry describes the Turcomans as ordinarily blonde. The mean cephalic index of the Mongols is 81, which is precisely that of the round barrow people, whom they resemble in their prognathism, their high cheek bones, and the squareness of the face. In all these

* Peschel, *Völkerkunde*, p. 59. Weisbach's measurements are somewhat higher. He gives for the Ruthenians 82.3, Poles. 82.9; Czechs, 83.1. Broca gives 82 8 for the Roumanians, and 84.83 for the Croats.

† Pösche, *Die Arier*, p. 136.

particulars the Cowlam skull, figured on page 42, agrees very closely with the Mongol type.*

The foregoing investigation has brought us to the conclusion at which Dr. Thurnam arrived many years ago. He says that to him it appears to be proved that the type of the Celtic skull, at least that of the dominant race in the bronze period in Britain, was of the brachycephalic "Turanian type." How the Celtic became the language of a people with this Turanian skull-form, and how this Turanian skull-form became the skull-form of a Celtic and so-called Indo-European people, are questions which he thinks are yet to be determined. Meanwhile, he continues, the idea of a connection between the ancient Celtic brachycephalic type, and that of the modern Mongolian or Turanian peoples of Asia, cannot be overlooked, and remains for explanation.

In the following pages an attempt will be made to find an answer to the enigma which Dr. Thurnam has so lucidly propounded.

5.—*The Iberians.*

It has been shown in the preceding section that some of the chief European races—the Celts, the Danes, the Umbrians, the Romans, and the Slaves—belong to the brachycephalic type found in the neolithic round barrows of Britain. We have seen that they stretch in a broad, continuous zone across Central Europe into Asia. We have now to trace the dolichocephalic long barrow race through Belgium, France, and Spain, and to identify them with their existing representatives.

The Iberians, as they may be conveniently called, were an Atlantic and Mediterranean race. They do not seem to have reached Germany or North-Eastern Europe. Their furthest extension in this direction is marked by a sepulchral cave at Chauvaux on the Meuse, not far from Namur, which contained skulls of the long barrow type, with a cephalic index of 71.8, together with pottery of the neolithic age.†

Before the arrival of the brachycephalic Ligurian race, the Iberians ranged over the greater part of France. We trace them in the valleys of the Seine, the Oise, and the Marne,‡ frequently in association with the remains of the Ligurian invaders.

If, as seems probable, we may identify them with the Aquitani, one of the three races which occupied Gaul in the time of Cæsar, they must have retreated to the neighborhood of the Pyrenees before the

* The Gristhorpe skull figured in the *Crania Ethnica*, Fig. 104, is strikingly Mongolian.

† Dawkins, *Cave Hunting*, p. 217.

‡ De Baye, *L'Archéologie Préhistorique*, p. 129.

beginning of the historic period. It is in this region, mainly in the valley of the Garonne, that their sepulchral caves are the most numerous.

Some of these caves, such as those at Bruniquel, Laugerie Basse, Aurignac, and Cro-Magnon, have been assigned to palæolithic times; but as this early date is now disputed,* and as the remains in these older caverns differ to some extent from those of the long barrows, it will be safer to begin by leaving all doubtful interments out of account, and confine ourselves to caves whose neolithic age is undisputed. For the determination of the characteristics of this Iberian or Aquitanian race no more typical sepulchre can be selected than the celebrated Caverne de l'Homme Mort in the Department of the Lozère. It lies in an inaccessible and desolate ravine which traverses a barren limestone plateau. Here the feeble Iberian race seems to have maintained itself for a time, after the more fertile surrounding lands had been seized by the brachycephalic intruders, whose descendants now occupy the region. In this cave some fifty persons must have been interred, and in fifteen cases the skeletons have been so well preserved as to admit of accurate measurement, and even of the determination of the sex.

No such extensive series of neolithic skeletons, all belonging to the same type and to the same period, has been found elsewhere. The skulls have been described by Paul Broca, the most eminent of French anthropologists,† whose careful measurements establish the identity of this race with the long barrow people of Britain. Like them, they were orthognathous and dolichocephalic, with oval faces, mild features, weak and slender forms, and short stature. They agree both in the shape of the skull and in the peculiar formation of the bones of the leg. The tallest of those buried in this cave slightly exceeded 5 feet 5 inches, the mean stature being 5 feet 3¾ inches. The mean stature of the skeletons in the Perthi-Chwareu cave in Denbighshire was 5 feet 4 inches, that of the long barrow people 5 feet 4½ inches.

The long barrow people of Britain were, as we have seen, extremely orthognathous. This is the most characteristic feature of the skulls in the Caverne de l'Homme Mort. The Guanches and the Corsicans are the most orthognathous of existing races, and next to them come the Spanish Basques. The men of the Caverne de l'Homme Mort plainly belong to the same racial group, being more orthognathous even than the Guanches.

These races agree also in constituting a great leptorhinic group, distinguished by an extremely low nasal index. This index is for the Guanches, 44.25; for the Berbers, 44.28; for the Spanish Basques, 44.71; and for the Caverne de l'Homme Mort, 45.46. They agree

* De Baye, *L'Archéologie Préhistorique*, p. 20.

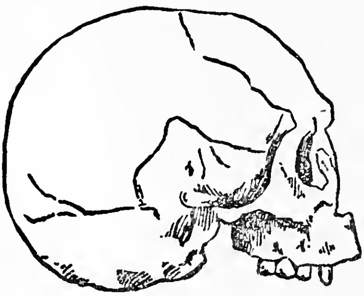
† Broca, *Revue d'Anthropologie*, vol. ii., pp. 1-53.

also in cranial capacity. The mean for male skulls is, for the Corsicans 1,552 cubic centimetres; for the Guanches, 1,557; and for the Spanish Basques, 1,574. In the Caverne de l'Homme Mort, it rises to 1,606.

The orbital index constitutes, in Broca's opinion, one of the surest tests of race. The orbital index of the Guanche mummies and of the skulls in the Caverne de l'Homme Mort is lower than that of the Spanish Basques, which is the lowest of any existing European race. It would be tedious and needless to discuss in detail the characteristics of the skulls in the neighboring sepulchral caves of this region. It may suffice to say that some of the most eminent of the French anthropologists—Broca, Mortillet, and De Quatrefages—consider that the people of the Caverne de l'Homme Mort were the survivors of an earlier race which inhabited the same region in the reindeer period, whose remains have been found in caves at La Madeleine, Laugerie Haute, Aurignac Laugerie Basse, and Cro-Magnon. This earlier race was tall, athletic, and prognathous. In spite of these differences the general osteological characters are the same, the cephalic index is the same, the mean index at Cro-Magnon being 73.34, and in the Caverne de l'Homme Mort, 73.22. Broca moreover affirms that of all the skulls with which he is acquainted, the nearest approach to the unique and exceptional skull of the old man interred in the Cro-Magnon cavern is to be found in two Guanche skulls in the Museum at Paris.

Certain characteristic peculiarities in the forms of the bones of the leg and the arm which distinguish the Cro-Magnon skeletons are seen in an attenuated form in several of the skeletons in the Caverne de l'Homme Mort,* as well as in some of the Welsh caves, notably in the Cefn Cave near St. Asaph and the Perthi-Chwareu Cave in Denbighshire, where we find interments which may be ascribed to remote ancestors of the people of the long barrows.†

The chief importance of the skeletons of the Cro-Magnon type is that in stature, prognathism, and the shape of the orbits they exhibit a greater approximation to the negro type than any others which have been found in Europe.



SKULL FROM GENISTA CAVE.

The Iberian race seems to have extended over the whole Spanish peninsula as well as the coasts and islands of the Mediterranean. In the Genista Cave at Gibraltar two skeletons were discovered with orthognathous and dolichocephalic skulls, which, according to Busk, resemble those found in the Perthi-Chwareu Cave in Denbighshire, and those of the

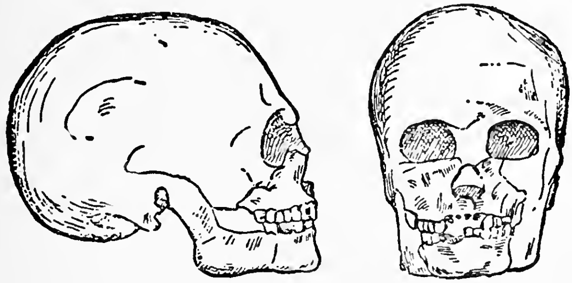
* Mortillet, *Le Préhistorique*, p. 610. † Dawkins, *Cave Hunting*, pp. 155-159

Spanish Basques. One of the Genista skulls had a cephalic index of 74.8 and an altitudinal index of 71.4, and one of the Denbighshire skulls had a cephalic index of 75 and an altitudinal index of 71. The agreement could hardly be more exact.*

In the Canaries we find an interesting survival of the customs of these French and Spanish troglodytes. The Guanches of Teneriffe must be regarded as an isolated branch of the Berber race, preserving in great purity the primitive type and mode of life. In Pliny's time the Canaries were uninhabited. When occupied by the Spaniards at the beginning of the fifteenth century the natives were still in the stone age, using caves both for habitation and sepulture. Mummied bodies from the Teneriffe caves are in most of the museums of Europe. The mean cephalic index of these mummies is 75.53; in the Genista Cave at Gibraltar it is 75.5; in the Denbighshire caves, 76.5; in the Caverne de l'Homme Mort, 73.22. The mean index of the Berbers is 74.63; of the Corsicans, 75.35; of the Spanish Basques, 76; of the ancient Egyptians, 75.58.

The same race inhabited Corsica, Sardinia, Sicily, and Southern Italy. In prehistoric caves of Italy and Sicily dolichocephalic skulls of the long barrow type have been found.† Seneca informs us that Corsica was peopled by Ligurians and Iberians. Pausanias says that the Sardinians were Libyans, a people whose existing representatives are the Berbers. We learn from Thucydides, and also from a passage of Ephoros preserved by Strabo, that the oldest inhabitants of Sicily were Iberians.

These statements are confirmed by modern craniological measurements. It is found that the dolichocephalic type maintains itself in Southern Italy; while Northern Italy is overwhelmingly brachy-



SKULL OF A MAN FROM HISSARLIK (BRONZE AGE).

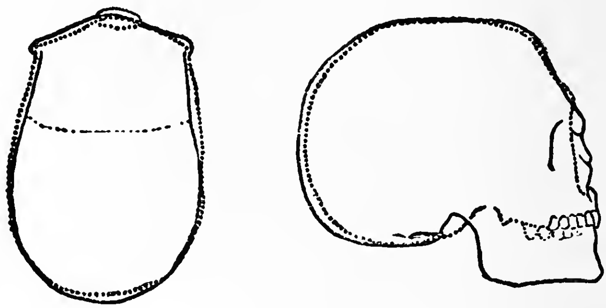
cephalic. In the former States of the Church Professor Calori found 24 per cent. of the inhabitants were dolichocephalic, with indexes below 74, and only .04 per cent. in Lombardy.

The ethnology of Greece is obscure, but it is probable that the

* Dawkins, *Cave Hunting*, p. 171. See also the figures on p. 72, *infra*.

† See pp. 52, 53, *supra*.

pre-Hellenic Autochthones belonged to the Iberian race, and that the Hellenic invaders were the same type as the Umbrians and Romans. Some light is thrown on this question by Dr. Schliemann's excavations at Hissarlik. He discovered four skulls, which have been put together and and described by Professor Virchow. One skull, decidedly brachycephalic, with an index of 82.5, was found in the second or neolithic stratum.* This may perhaps be referred to the Ligurian race, which it resembles in some striking features. The other three skulls,† found in the burnt city, which is of the bronze age, have indexes respectively of 68.6, 71.3, and 73.8, giving a mean index of 71.23, which agrees with that of the long barrow skulls. They are orthognathous, and in their outline bear some resemblance to those from the Genista cave at Gibraltar, though the cephalic index is lower.



—— TROY.
.... GIBRALTAR.
SKULLS FROM TROY AND GIBRALTAR SUPERIMPOSED.

Unfortunately all the skulls from Hissarlik were so fragile and imperfect as to make it unsafe to draw from them any positive conclusions. Virchow doubtfully refers them to the old Hellenic type, and it is possible that he may be right.

The Iberian race was probably of dark complexion, with black hair and eyes. Their presumed descendants, the Welshmen of Denbighshire, the Irish of Donegal and Kerry, the Corsicans, the Spanish Basques, and the Berbers are swarthy. On the other hand, the Kabyles are of lighter tint, and blue eyes are not uncommon among them, while some of the Guanche mummies appear to have been fair-haired. The Tuariks of the Sahara are fair-haired and blue-eyed.

But the complexion and the color of the hair and eyes is of less value as an anthropological characteristic than the shape of the skull and of the orbits of the eyes. It is believed that under certain circumstances fair races may become dark, and dark races light, the cuticle, however, being affected sooner than the hair or the iris of the eyes. In the southern, as in the northern hemisphere, we find a zone of

* See p. 67, *infra;* Schliemann, *Ilios*, p. 271. † *Ibid.*, pp. 508, 511.

lighter colored people running through the temperate regions. The Caffres of South Africa are not so black as the negroes of the tropics, and in South America the Patagonians and the Fuegians are lighter in tint and taller in stature than the races nearer the equator. Some of the Araucanians of Chili are almost white. The physical strength and great stature which distinguish the northern Europeans are reproduced under similar conditions of climate among the Patagonians.

The Cro-Magnon people were exclusively hunters and fishers ; they had no domestic animals and no cereals. They were acquainted with fire, and were clad in skins, which they stitched together with bone needles. They wore collars and bracelets of shells strung together, and painted or tattooed themselves with metallic oxides. They were not destitute of religious ideas, since they believed in a future life ; the care bestowed on the interments and the objects deposited with the deceased proving that they thought the spirits of the dead had wants beyond the tomb, and were able to make use of ornaments and weapons.*

From distant parts of Europe where the remains of the Iberian race are found there is evidence that they were occasionally addicted to cannibalism. Such evidence is supplied by human bones which have been broken in order to extract the marrow. The best authenticated cases come from a cave in the island of Palmaria in the Gulf of Spezzia,† from Keiss in Caithness,‡ and from the Césareda Caves in the valley of the Tagus.§

If, as is contended by Broca and De Quatrefages, the Cro-Magnon people exhibit a remote ancestral type of the Iberian race, the question of the ultimate origin of the Iberians would be greatly simplified. Broca considers that their resemblance to the Berbers shows that they immigrated into Europe from Africa, while the resemblance of the Guanche and Berber skulls to those of the ancient Egyptians allies them to the great Hamitic stock, the Cro-Magnon skeletons forming a link between the Berbers and the negroes.

On the ground that the Iberian type is found as far north as Caithness, Professor Boyd Dawkins believes in its Asiatic origin. The difficulty in the way of this view is that, while the Iberian type of skull stretched continuously in neolithic times from Britain through France and Spain to Africa, it has not been found in Northern Europe east of Namur.

If, however, the abnormal Neanderthal skull may be regarded as a remote prototype of the typical Scandinavian skull, and if the equally abnormal Cro-Magnon skull may be regarded as an archaic form of the Iberian type, the difficulty would not be so great, as these two

* De Quatrefages, *Hommes Fossiles*, p. 68.

† Dawkins, *Cave Hunting*, p. 259. ‡ *Ibid.*, p. 197. § *Ibid.*, p. 146.

abnormal types agree more closely than the less savage types which prevailed in more recent periods.

6.—*The Scandinavians.*

In Britain three cranial types characterize the three ages of stone, bronze, and iron. The "Iberian" type is distinctively neolithic, the "Celtic" type prevailed in the bronze period, while in graves of the iron age a new type appears, which we may call the "Scandinavian" or "Teutonic."

The skulls from these Anglo-Saxon graves, although dolichocephalic, like those from the long barrows, are unmistakably dissimilar. The forehead is more retreating, the cranial vault lower, and the mean cranial capacity much less, in the one case amounting to 1,524 cubic centimetres, or 93 cubic inches, in the other only to 1,412 cubic centimetres, or 86 cubic inches.

The bony structure of the face is also different. The Iberians were highly orthognathous, the Anglo-Saxons somewhat prognathous. The Anglo-Saxon jaw was powerful, the Iberian weak. The Iberian face, during life, would appear feeble, owing to its narrowness, and especially to the long, weak chin, whereas the facial bones of the Anglo-Saxons were massive. Moreover, one race was tall, often over six feet, the other exceptionally short.

An earlier and more typical form of the Teutonic skull, which is known as Ecker's "Row Grave" type, with a mean index of 71.3, has been found in numerous graves of the iron age in the south-west of Germany. These are assigned to Frankish and Alemannic warriors of the fourth and following centuries. This Row Grave type differs hardly at all from a type with a mean index of 70.7 found in graves of the post-Roman period in Western Switzerland, which is called the Hohberg type by the authors of the *Crania Helvetica.* That the Hohberg type is that of the Burgundians has been established by the recent discovery at Bassecourt, some eighteen miles south-west of Basel, of a Burgundian cemetery containing five skulls of the Hohberg type, with indexes varying from 70.1 to 73.9, giving a mean index of 72.3.*

The Row Grave men were tall, often upwards of six feet in height, in which they resemble the Swedes, who are the tallest existing race in Europe. The forehead is narrow, the brow low and retreating, the cranial vault low, the nose narrow but prominent, the orbital ridges are well marked, and the back of the skull greatly developed.

This Row Grave type of skull having been found over the whole region of Gothic, Frankish, Burgundian, and Saxon conquest, as well

* Kollman, *Craniologische Gräberfunde in der Schweiz*, p. 360. (Verhandlungen der Natürforschenden Gesellschaft in Basel, vol. vii., 1882.)

in England as in France, Spain, Italy, and Eastern Europe, it must be taken to represent the type of the old Teutonic race. It still survives in Sweden, as Ecker has shown by a comparison of his Row Grave skulls, whose mean index is 71.3, with two modern Swedish skulls, having indexes of 69.5 and 72.2.

Owing probably to the infusion of Slavonic or Celtic blood this type is practically extinct in other Teutonic lands, with the exception of certain Frisian districts, notably the islands of Urk and Marken in the Zuyder Zee, where Virchow claims to have discovered pure descendants of the old Frisian race. These islanders are more platycephalic even than the Hottentots, the mean altitudinal index being as low as 69.8, while in a characteristic skull from Marken, which Virchow has figured, it is only 67. Nowhere else are skulls of the Neanderthal type so numerous as here.*

In the neolithic age this platycephalic type extended from the mouths of the Rhine to the Neva, and as far south as Galicia. It has been found by Schaffhausen in Westphalia and by Virchow east of St. Petersburg. In prehistoric Pomeranian graves Dr. Lissauer has found platycephalic skulls with an index of 70, and a cranial capacity of less than 80 cubic inches, lower than that of the Bosjemen, and not far above that of the Neanderthal skull, which is estimated at 75 cubic inches. Nilsson and Von Düben affirm that in the neolithic period, and throughout the bronze and iron ages, down to the present time, the same type has continuously prevailed in Sweden.

The lands vacated by the Goths, Vandals, and Burgundians in Northern Germany were re-occupied by brachycephalic Slaves, who have since been Teutonized.

Denmark, though Scandinavian in speech, is no longer purely Scandinavian in blood. The modern Danes belong rather to the brachycephalic Slavo-Celtic type; but whether by blood they are Celts or Slaves is doubtful.

At all events the change of type began early, as is proved by the neolithic tumulus at Borreby, in the island of Falster,† where we find dolichocephalic skulls of the Row Grave type, with indexes as low as 71.8, but mostly between 72 and 73, together with brachycephalic skulls resembling those of the British round barrows, with indexes usually between 80 and 83, but in one case as high as 85.7. No craniologist would admit that they can belong to the same race.

The interments in the Borreby tumulus seem to indicate that the dolichocephalic aborigines were conquered, and probably Aryanized, by brachycephalic invaders of the same Slavo-Celtic race which buried in the round barrows of Britain, while the dolichocephalic skulls from Borreby must be assigned to the people of the shell mounds.

* Virchow, "Anthropologie der Deutschen," in *Transactions of the Berlin Academy* for 1871, p. 52.

† See p. 48, *supra*.

The most undoubted representative skull of this kitchen midden race comes from Stængenæs in Sweden, where, in 1844, Nilsson discovered in an undisturbed portion of a kitchen midden, at a depth of 3 feet, the skeleton of a man whose stature exceeded 5 feet 10 inches, and whose skull was of a marked dolichocephalic type, with an index between 72 and 73.*

The kitchen middens belong to the early part of the neolithic age, if indeed they are not mesolithic, bridging over the supposed hiatus between neolithic and palæolithic times. The French Anthropologists are inclined to believe that the ancestors of the Scandinavian race may be traced still further back, and be identified with the savages who peopled Northern Europe in the palæolithic age. But as some doubt attaches to this conclusion, we may provisionally designate them as the Canstadt race—a name given to them by De Quatrefages and Hamy from a skull found in 1700 at Canstadt, near Stuttgart, associated, it is said, with bones of the mammoth. A similar skull was discovered in 1867, together with remains of the mammoth, at Eguisheim, near Colmar, in Alsace.

The celebrated Neanderthal skull (index, 72), found near Dusseldorf in 1857, is less human and more simian in character than any other known skull, but is nevertheless classed by Hamy and De Quatrefages as belonging to their Canstadt type. Its precise age is doubtful, and it would be unsafe to regard it as the type of a special race, since its characteristics, as we shall presently see, have been occasionally reproduced in modern times.

A more favorable specimen of this type is the celebrated skull (index, 70.52) which was found seventy miles south-west of the Neanderthal in a cavern at Engis, on the left bank of the Meuse, eight miles south-west of Liège. It was embedded in a breccia with remains of the mammoth, the rhinoceros, and the reindeer. It has usually been referred to the the quaternary period, but as a fragment of pottery was found in the same deposit it is possible that the contents of the cave may have been swept in by water, so that the skull may be only of neolithic age.

Of this Engis skull Virchow writes: "It is so absolutely dolichocephalic that if we were justified in constituting our ethnic groups solely with reference to the shape of the skull, the Engis skull would without hesitation be classed as belonging to the primitive Teutonic race, and we should arrive at the conclusion that a Germanic population dwelt on the banks of the Meuse prior to the earliest irruption of a Mongolic race."

In the oldest skulls of the Canstadt race the ridges over the eyes are greatly developed, the cranial vault is low, the forehead retreat-

* Nilsson, *Les Habitants primitifs de la Scandinavie*, quoted by De Quatrefages, *Hommes Fossiles*, p. 19; cf. Hamy, *Précis*, p. 129.

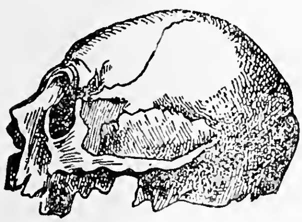
ing, the eye orbits enormous, the nose prominent, but the upper jaw is not so prognathous as the lower. This primitive savage, the earliest inhabitant of Europe, was muscular and athletic, and of great stature. He had implements of flint, but not of bone, and was vain of his personal appearance, as is proved by his bracelets and necklaces of shells. He was a nomad hunter, who sheltered himself in caves, but was without fixed abodes, or even any sepulchres.

The chief interest that attaches to these repulsive savages is that French anthropologists consider them to be the direct ancestors of their hereditary enemies the Germans, while German anthropologists assert that the Teutons are the only lineal representatives of the noble Aryan race. How far this contention can be maintained we shall hereafter see.

That the earliest inhabitants of Europe belonged to the Canstadt race may, however, probably be granted, since skulls of this type have been found underlying those of the Iberian and Ligurian races in the very oldest deposits at Grenelle ;* while in many cases there are indications, more or less trustworthy, of the Canstadt race having been contemporary with the extinct pachyderms.

Its chief habitat seems to have been the valley of the Rhine, but it extended to the south as far as Würtemberg, and to the east as far as Brüx in Bohemia. Only at a later time, when the reindeer had retreated to the north, it reached the shores of the Baltic.

Though this type has now become extinct in Germany, owing to the prepotence of the Celtic or Turanian race, and though it has been favorably modified by civilization in Scandinavia, yet even in modern times we find curious instances of atavism or reversion to an earlier type. These cases are found chiefly among men of Norman or Scandinavian ancestry. Such may occasionally be noticed in the Scandinavian districts of England. The skull of Robert Bruce, who was of pure Norman blood, exhibits a case of such reversion. Another case is that of the skull of St. Mansuy, or Mansuel, the Apostle of Belgic Gaul, who in the fourth century became Bishop of Toul in Lorraine. A still more remarkable case is that of Kai-Likke, a Danish gentleman who lived in the seventeenth century, whose skull is of the Neanderthaloid or Canstadt type, with receding forehead, and an enormous development of the supraciliary ridges.†



SKULL OF ST. MANSUY, BISHOP OF TOUL.

Zeuss, Pösche, Penka, and other writers ‡ have collected a large

* See p. 69, *infra*.

† De Quatrefages, *Hommes Fossiles*, pp. 61-64.

‡ Zeuss, *Die Deutschen*, p. 50, *seq.;* Pösche, *Die Arier*, p. 25, *seq.;* Penka, *Or. Ar.*, p. 122 ; Diefenbach, *Or. Eur.*, p. 161, *seq.;* De Belloguet, *Eth. Gaul.*, ii., p. 64, *seq.*

number of passages from ancient authors which show that the Germans had the tall stature, yellow hair, and blue eyes of the modern Scandinavians. Ausonius describes the blue eyes and yellow hair of a Suevic maiden. Lucan mentions the *flavi Suevi*, Claudian the *flavi Sicambri*, Martial the *flavorum genus Usipiorum*.

Tacitus speaks of the *truces et cærulei oculi*, *rutilæ comæ*, *magna corpora* of the Germans, and according to Calpurnius Flaccus, *Rutili sunt Germanorum vultus et flavi proceritas*, and Procopius describes the Goths as tall and handsome, with white skins and fair hair.

There is a superficial resemblance between the Teutons and the Celts, but they are radically distinguished by the form of the skull. No anthropologist would admit that the Row Grave skulls and the round barrow skulls could belong to the same race. Both races, however, were tall, large-limbed, and fair-haired. But the pink and white complexion of the Teuton is different from the more florid complexion of the Celt, who is inclined to freckle. The eyes of the pure Teutons are blue, those of the Celts green, gray, or grayish-blue. The hair of the Teutons is golden; that of the Celts is often fiery red. In the Roman period the Gauls are described as resembling the Germans, but not so tall, so fair, or so savage.

De Quatrefages has conjectured that this race may have roamed farther to the East. He thinks the type may be recognized in the Ainos of Japan and Kamtshatka, and in the Todas of the Neilgherries, who bear no resemblance to any of the contiguous tribes. Both the Ainos and the Todas are fully dolichocephalic, differing in this respect from the Japanese and Dravidians, who are brachycephalic. The profile is of the European type, and instead of the scanty beard of the Mongolians and Dravidians, they are as amply bearded as the Scandinavians, and, like many North Europeans, they have much hair on the chest and other parts of the body.

7.—*The Ligurians.*

Cæsar found three races in Gaul, differing in language, laws, and customs. The Aquitani in the South-West have been identified with the long barrow "Iberian" race of Britain; the Belgæ in the North-East were probably of the same race as our own round barrow people; while the Celtæ occupied the central region between the Garonne to the South-West, and the Seine and the Marne to the North-East. Who these Celtæ were is one of the problems of ethnology.

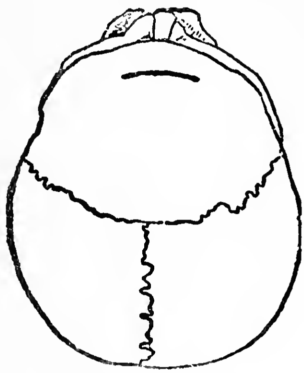
A few years ago they were unhesitatingly identified with the speakers of what we call the "Celtic" languages, the Irish and the Welsh. But in two very ingenious papers, whose arguments have convinced many of the French anthropologists, Broca* has maintained that there

* Broca, "La Race Celtique Ancienne et Moderne" (*Revue d'anthropologie*, vol. ii., pp. 577–628); and "Qu'est ce que les Celtes?" (*Mémoires*, vol. i., p. 370).

never have been any Celts in Great Britain or Ireland, that no British people ever called themselves Celts, or were so called by ancient writers, and that they do not possess the physical characters of the Celts of history. The real Celts, he considers, are the people of Central France, who are the descendants of the Celts of Cæsar; so that the term Celt is an ethnological misnomer, if applied to either of the two British races by whom what is commonly called "Celtic speech" is spoken—either the tall, red-haired brachycephalic Irishman and Scot, or the short, dark, dolichocephalic race of Donegal, Galway, Kerry, and South Wales.

A small portion of the Bretons, he says, are the only Celts by race who speak a "Celtic" language; and in this case their Celtic speech was acquired from the fugitives who fled to Brittany at the time of the Saxon Conquest of Wessex.

The hilly region of Central France, which was occupied by the Celts of Cæsar, has been continuously inhabited, as Broca maintains, by their lineal descendants, a short, dark, brachycephalic race, who are the true Celts of history and ethnology, as distinguished from the so-called Celts of philology and popular archæology. This type, which cannot with any certainty be traced among the existing population of Great Britain, or in the British barrows, is found in its greatest purity in Auvergne, Dauphiny, Savoy, the Grisons, and the Maritime Alps.


SKULL OF AUVERGNAT.

There can be no doubt, however that, at the time of the Roman Conquest, Cæsar's Celts, the people of Central Gaul, spoke what we call a "Celtic" language; but, as will hereafter be shown, there are reasons for believing that this may have been only an acquired tongue, imposed on them by the Belgic Gauls, and not their primitive non-Aryan form of speech. This acquired tongue was, however, the Aryan language of the so-called "Celtic" people of Britain, and hence modern philologists have assumed an identity of race when there was merely an identity of language.

The true "Celts" of Central France are of short stature, black-haired, and extremely brachycephalous, having a mean index of 84. The so-called Celts of the British round barrows were, as we have seen, tall, with hair probably rufous or flavous, and only moderately brachycephalous, with a mean index of 81. Many English writers, ignoring Broca's arguments, identify the two races; and they contend that the shorter stature and the darker hair of the race of Central France arose from a union of the short, dark, dolichocephalic Iberians with the tall, fair, brachycephalic people of the round barrows. But in such case the resulting type would be intermediate between the two parent types; and it is difficult to understand how a race with an index of 72 uniting with another having an index of 81 should have resulted in a race with an index of 84, or how the cross of a tall, fair race with a short, dark race should have produced a hybrid race shorter and darker than either of the parent races.

These difficulties will have to be explained before we are entitled to identify the two brachycephalic "Celtic" races—that of Auvergne and that of the round barrows.

In any case it must be admitted that the popular usage of the word "Celtic" is unfortunate; the Celts of history and ethnology having probably only an indirect linguistic relation to the Celts of philology. The blunder, if it is a blunder, cannot now be remedied; to use the word Celtic in its strict historical and ethnological sense would be to introduce endless confusion. The word "Celtic" is too firmly established as a linguistic term to be now displaced, and it has therefore not been discarded in these pages. But if for convenience it has to be employed in its ordinary philological signification, it becomes all the more needful to find some other name for the short, dark, brachycephalic race who are claimed as the true Celts of ethnology and history.

From their physical resemblance to the Lapps, the term "Lappanoïde" has been proposed by Prüner-Bey. But as this involves the assumption of a genealogical relationship, which, though not improbable, is only an ethnological hypothesis, it will be better to select some other name. Rhætian, Savoyard, Breton, and Auvergnat have been suggested. Breton is objectionable, as, though the people of the southern part of Brittany are of this race, those of the northern coast were fugitives from the Saxon invasion of Wessex, and belong mainly, as Broca has shown, to the Silurian race. Auvergnat is better than either Rhætian or Savoyard, as Auvergne is in the heart of Cæsar's "Celtic" region. The term Ligurian is, however, very generally used on the ground that the modern Ligurians, who were never Celticized in speech, may claim to be the purest descendants of this race, having an index of 86, higher even than that of the Auvergnats.

The resemblance of this type to the Lapps cannot be overlooked. The mean cephalic index of the Auvergnats is 84 according to Broca, and 84.6 according to Durand. That of the Lapps is 84 by Prüner-Bey's measurements, and 85 by those of Broca. The Auvergnats also resemble the Lapps in their swarthy complexion and their black hair and eyes. But the chief reason for identification is that the Lapps and Auvergnats agree in having the smallest parietal angle of any existing races—that is, the head is abnormally narrow across the cheek bones, and wide at the temples. The mean parietal angle of the Lapps is 5° 30′, with a minimum angle of —3°; the mean angle of the Auvergnats is 2° 30′, with minimum of —5°. This peculiarity is seen in the front view of the skull of a girl found by Dr. Schliemann in the second or neolithic stratum at Hissarlik.

SKULL OF A YOUNG WOMAN FROM HISSARLIK (STONE AGE).

Among the Eskimo, whose heads are pyramidal, the mean parietal angle is as high as 15°, and it is 10° among the Guanches. All the Turanian races, with their broad cheek bones, have a high parietal angle.

Significant also, but less decisive, is the agreement in stature. The Lapps are the shortest race in Europe, their average stature being 5 feet 2 inches. The Auvergnats are not only the shortest race in France,* but the shortest race who now speak any Aryan language.

Attempts have been made to connect the Ligurians with the Finns rather than with the Lapps. The difficulty, or rather the facility, of such contentions arises from the fact that the Finns are not of homogeneous race. The stature, the color of the hair and eyes, and the cephalic indexes differ. Some of them resemble the Slaves, others approach the Swedes, and some share the characteristics of the Lapps,

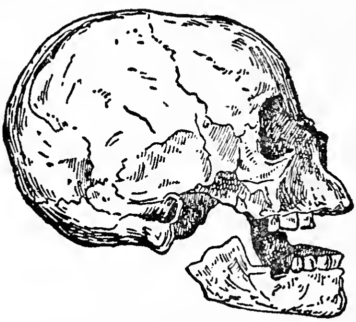
* French conscripts who measure less than 5 feet 1½ inches are exempted from serving. In the Department of the Puy-de-Dôme and the two adjacent departments, the Haute Vienne and the Corrèze, which are the home of the Auvergnat race, the exemptions are from 15 to 19 per cent., while in Belgic Gaul they are under 5 per cent. In the Auvergnat Departments the number of conscripts above 5 feet 8 inches is only 3 per cent.

whose language is an archaic form of Finnic speech. The Lapps, however, are orthognathous, and the Finns mostly slightly prognathous. Broca gives 80.39 as the mean index of the Esthonian Finns, and 83.69 as that of the Finns of Finland. The mean stature of the Finns of Finland is given as 5 feet 3 inches.

There is less difficulty in determining the neolithic ancestors of the Ligurians. We must search the dolmens and sepulchral caves of Western Europe for a race combining short stature with a very high cephalic index.

The earliest vestiges of any people who answer to this description have been discovered at Grenelle near Paris.* Here, in the alluvium and the underlying gravels, deposited in a bend of the ancient bed of the Seine, skulls of three successive races have been found. The lowest, and therefore the oldest, beds of gravel contain skulls of the Canstadt or Scandinavian type, dolichocephalic and platycephalic resembling the Stængenæs skull. In the alluvium which overlies the gravel, and at a depth of from 9 to 12 feet from the surface, there are dolichocephalic skulls of the Cro-Magnon or Iberian type. Above these, at a depth of from 4 to 7 feet, are the remains of a short brachycephalic race, quite different from the other two, with a mean stature of five feet 3½ inches, and a mean cephalic index of 83.6—measurements which accord very closely with those of the Auvergnats.

Farther to the north, certain limestone caves near Furfooz, in the valley of the Lesse—a small river which joins the Meuse near Dinant in Belgium—have yielded remains of one or possibly two short brachycephalic races. A cave called the Trou-Rosette † was inhabited by a race with the high index of 86. In a neighboring cave, called the Trou-de-Frontal, skulls were found with indexes varying between 79.8 to 81.4. The mean index is 80.35, the mean index of five Esthonian skulls at Paris being 80.35.



SKULLS FROM THE TROU-DE-FRONTAL.

The stature of both of the Furfooz races was short. The tallest skeleton measured 5 feet 4 inches, the shortest 4 feet 11 inches. The mean stature of one race was 5 feet 2 inches; that of the other was just over 5 feet. The Trou-Rosette skulls bear a resemblance to those of the Lapps; the Trou-de-Frontal type, which may still be recognized among the inhabitants of the

* De Quatrefages, *Hommes Fossiles*, p. 72; Penka, *Origines Ariacæ*, p. 91; Hamy, *Précis de Paléontologie Humaine*, p. 252.

† Hamy, *Précis*, p. 354.

valley of the Lesse, and among the peasants who frequent the markets of Antwerp, is more prognathous and nearer to the Finns.

Of the stage of civilization attained by the Grenelle race we know nothing; but the Furfooz races have left many traces of their industries in the caves which they inhabited, and in which they also buried their dead. They seem to have been a peaceful people, possessing no bows and arrows, or weapons for combat, but merely javelins tipped with flint or reindeer horn, with which they killed wild horses, reindeer, wild oxen, boars, goats, chamois, and ibex, as well as squirrels, lemmings, and birds, especially the ptarmigan.

Some of these animals, especially the reindeer, the ibex, the chamois, and the ptarmigan, prove that the climate was then subarctic. As the climatal conditions grew less severe some of these people may have followed the reindeer and the ptarmigan to more northern latitudes, while others accompanied the ibex and the chamois to the Alps, or conformed themselves, in the hilly regions of Central France, to new conditions of existence.

Their clothing consisted of skins, sewn together with bone needles. They tattooed or painted themselves with red oxide of iron, and wore as ornaments shells, plaques of ivory and jet, and bits of fluorspar. But the most noticeable fact is that the materials for their ornaments and weapons were brought from distant regions far to the south and south-west, which are now inhabited by a similar short brachycephalic race, while they seem to have been unable to avail themselves of the natural resources of the contiguous districts to the north and north-east, where the ethnic type is different. The flints for their implements were not obtained from the chalk formation of Hainault, a few miles to the north, but must have been brought from Champagne, and even from Touraine, more than 250 miles distant in a direct line. The jet came from Lorraine, and the shells from Grignon. Manifestly these people of the valley of the Lesse—some fifteen miles south of Namur—could range upwards of 300 miles to the south-west, but not more than twenty-five miles to the north, or they would have got their shells from Liège instead of from the Loire, and their flints from Hainault instead of from Champagne. Here, therefore, we recognize an ancient ethnic frontier. The people of the Lesse were unable to pass the line of the Sambre and the Meuse; the hills of Hainault must have been held by a hostile and more powerful race.*

That this was the case is also indicated by the fact that near Mons, forty miles-north-west of the Lesse, deposits of flint instruments have been discovered, differing in type as well as in material from those found in the valley of the Lesse. The latter agree in type with those of the Dordogne in Central France, while the implements from Mons agree with those found in the valley of the Somme and other districts

* De Quatrefages, *Hommes Fossiles*, p. 74.

of Belgic Gaul. At a later time these distinctions disappear, the weapons are made of Hainault flint, and the types are the same as in the Hainault district.*

It would appear, therefore, that in the early neolithic age the Auvergnat race was pressed back in Southern Belgium by a more powerful northern people, who, we may conjecture, were the ancestors of the Belgic Gauls.

But while the Auvergnat race was in retreat on their northern frontier they were themselves encroaching on the territory of the feebler Iberian people to the south.

The artificial sepulchral grottoes of the Marne, excavated in the soft chalk of this region, form the transition between the natural caves used for sepulture on the Lesse, and the later dolmens of Central France. In these grottoes we find evidence that the brachycephalic people of the Lesse lived in peaceable association with the dolichocephalic Iberian race. They contain skulls with cephalic indexes varying from 71.65, which agrees with that of the Iberians, up to 85.71, which is that of the Furfooz people.

Three hundred miles farther south is the Department of the Lozère, now inhabited by the brachycephalic Auvergnat race. The Caverne de l'Homme Mort and other early sepulchral caves of this district contain only dolichocephalic skulls of the Iberian type.† But in the dolmens, which are of later date, M. Prunière has found numerous skulls of a pronounced brachycephalic type, mingled with a few decidedly dolichocephalic, and others of mixed type. Hence we conclude that the cave men were invaded by the dolmen builders. That the invaders met with resistance is proved by the fact that in some of the cave interments arrow-heads, of types believed to have been used only by the dolmen builders, are found embedded in the bones.‡ Hence De Quatrefages concludes that early in the neolithic age the dolichocephalic autochthones of this region were attacked by an intrusive brachycephalic race in a higher state of civilization; that the two races ultimately amalgamated; and that, finally, the dolichocephalic race was either absorbed or retired to the south-west, where, in the district between the Lozère and the Aveyron, there are dolmens containing only dolichocephalic skulls.§

It is believed that the Spanish Basques represent the earlier race, the Auvergnats the invaders, and the French Basques the mixed race.

The chief importance of these researches consists, as we shall hereafter see, in their bearing on the moot question of the linguistic affinities of the Basque speech.

The Auvergnats are separated from the Savoyards, who belong to

* De Quatrefages, *Hommes Fossiles*, p. 104.

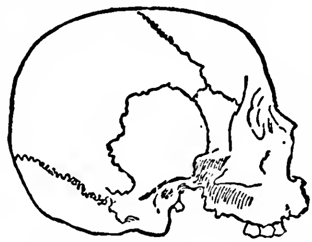
† See p. 54, *supra*.

‡ De Quatrefages, *Hommes Fossiles*, p. 99.

§ *Ibid.*, p. 62.

the same type, by the valley of the Rhone, which is inhabited by a later intrusive race of much higher stature.

We are informed by Zosimus that there were "Celts" in Rhætia.* Here, consequently, if Broca's theory as to the Celts is correct, we ought to find traces of a people of the Auvergnat type. In the prehistoric graves of Eastern Switzerland, the ancient Rhætia, we find brachycephalic skulls which constitute what is called the Disentis type by the authors of the *Crania Helvetica*.† The mean cephalic index is 86.5, higher than that of any existing race. The nearest approach to it is 86, which Broca gives as the mean index of the modern Ligurians, and 85, which is that of the Lapps. A skull of the Disentis type was found in the neolithic stratum of the cone of the Tinière, to which an antiquity of from 6,000 to 7,000 years has been assigned by M. Morlot.‡



RHÆTIAN SKULL (DISENTIS TYPE).

The pile dwellings in the lakes of Northern and Western Switzerland were, as we have seen,§ probably erected by the Helvetians, a people akin to the Umbrians and the Belgic Gauls.

The Helvetic and Rhætian skulls, though both brachycephalic, are very different. The first agree with those of the round barrow people of Britain, the second with those of the Liguarians, and to some extent with those of the Lapps.

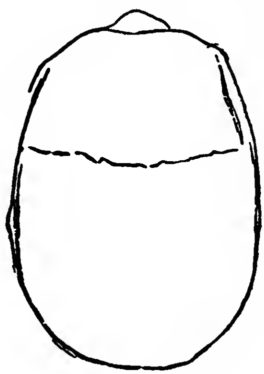
The mean index of ninety-five skulls from British round barrows is 81; that of seven skulls from the lake dwellings is 80.3. The index of the Disentis type varies from 81.8 to 97.5, the mean being 86.5. The index of the modern Lapps is 84 or 85, and it seems formerly to have been even higher, skulls from an ancient Lapp cemetery giving an index of 90.28. The mean cranial capacity of the round barrow people was 98 cubic inches, of the Helvetii 97, of the Rhætians 83. The Rhætians, like the Lapps, are orthognathous, while the round barrow people were prognathous.

The authors of the *Crania Helvetica* are of opinion that the Rhætian type is quite distinct from that of the British round barrows and of the Danish tumuli. On the other hand, Dr. Thurnam maintained that the brachycephalic races of Britain, France, and Denmark are cognate with the modern Finns. Professor Huxley goes further, and considers that the Disentis type, the South Germans, the Slaves, and the Finns, all belong to one great race of fair-haired, broad-headed Xanthochroi, "who have extended across Europe from Britain to Sarmatia, and we know not how much further to the east and south."

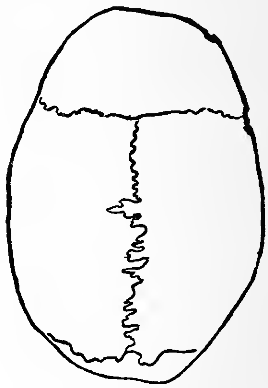
Professor Boyd Dawkins, in spite of the difference of stature, thinks

* Zeuss, *Die Deutschen*, p. 229. † His and Rütimeyer, *Crania Helvetica*, passim.
‡ See p. 34, *supra*. § See p. 50, *supra*.

the short Furfooz type is the same as that of the tall people of the round barrows of England, and of the neolithic tombs at Borreby and Moen.* With all deference to the opinions of these high authorities, it seems more in accordance with the evidence to class the tall people of the round barrows, who were almost certainly xanthous in hair and complexion, with the tall, red-haired Ugric race, and to class the short, brachycephalic race of France, Belgium, and Switzerland, who were almost certainly dark, with the Lapps, or possibly with some of the Finns. But as stature, prognathism, and the color of the hair and eyes are more variable characteristics than the shape of the skull and of the orbits, it is possible that the two brachycephalic types, the Celts of ethnology and the Celts of philology, may be remote branches of the same race, which, with Dr. Thurnam, we may call "Turanian." But for the purposes of the present inquiry it has seemed safer to consider them provisionally as distinct, more especially as the short, dark Ligurian race appear in Europe at a much earlier period than the tall, fair Celto-Slavic people. Certain linguistic theories bearing on the possible ultimate relationship of the two brachycephalic races will be discussed in a subsequent chapter.



SKULL FROM GENISTA CAVE, GIBRALTAR.



DOLICHOCEPHALIC SILURIAN SKULL FROM RODMARTON, GLOUCESTERSHIRE.

It has been already observed† that it is not impossible that the two dolichocephalic races may have descended, at some very remote period, from common ancestors. If, as De Quatrefages and Broca maintain, we may take the Cro-Magnon race as the ancestral type of the Iberians, and the Canstadt race as that of the Scandinavians, we find in the very oldest skulls a certain approximation of type. There was a time when the only inhabitants of Europe were dolichocephalic, and it is not impossible that the Neanderthal and Cro-Magnon people may have been descended from a common palæolithic stock, and both

* Dawkins, *Cave Hunting*, p. 238.

† See pp. 59, 60, *supra*.

of the brachycephalic races from another. We should thus have only two primitive races to deal with, instead of the four which we recognize in tombs of the later neolithic age.

CHAPTER III.

THE NEOLITHIC CULTURE.

1.—*The Continuity of Development.*

THIRTY years ago, when the science of prehistoric archæology was in its infancy, the so-called "Finnic theory" was very generally accepted. The philologists having determined to their own satisfaction that the Aryans had migrated from Central Asia, the archæologists proceeded to identify them with the introducers of metal into Europe. They affirmed that prior to the Aryan migration neolithic Europe was occupied by Finnic races, who were encountered and exterminated by Aryan invaders armed with the bronze weapons which they brought with them from the East. It was also asserted that these Aryan invaders introduced most of our domesticated animals and cultivated plants, and were also in possession of an elaborate mythology, consisting chiefly of storm gods, dawn maidens, and solar heroes.

The evidence in support of these theories has now to be investigated, and we have to frame from the evidence of linguistic palæontology an account of the civilization attained by the undivided Aryans, and to compare it with the picture of neolithic culture as disclosed by the science of prehistoric archæology.

The theory that bronze weapons were introduced into Europe by a conquering people coming from the East has been overthrown, despite the arguments of M. Troyon,* by the evidence afforded by the Swiss lake dwellings, which establish the fact that bronze implements were gradually introduced among a neolithic population by the peaceful processes of barter. The successive "relic beds" superimposed one upon another prove that many of the lake settlements were founded in the age of stone, and passed through the age of bronze to the age of iron. No traces of any such hiatus as the Finnic theory demands have been discovered. The fact that with very few exceptions these lake settlements are exactly opposite to some modern town or village built upon the shore† shows that habitation has been usually continuous down to our own days. Evidently, as population increased, and

* Troyon, *Habitations Lacustres des temps anciens et modernes.* M. Troyon's conclusions are completely refuted by Keller, *Lake Dwellings*, p. 667.

† Keller, *Lake Dwellings*, p. 671.

life became more secure, the limits of the settlement were extended from the water to the land, and the pile dwellings, being no longer needed, gradually fell into disuse.

From an examination of the pile dwellings in the valley of the Po, Helbig has proved that the same gradual transition from stone to bronze took place among the Umbrians, an Aryan people. Here, however, at some time in the bronze age, the Umbrian civilization was suddenly overthrown by the invasion of the Etruscans, none of these Italian settlements reaching into the age of iron.

Thus the pile dwelling opposite Peschiera, on the Lago di Garda, was founded in the stone age, and was in continuous occupation through the age of copper to the age of bronze.* The remains of the settlement in the Lake of Fimon are specially instructive, as it must have been founded very soon after the Umbrians arrived in Italy, and was destroyed before they had passed from the pastoral to the agricultural stage. There are two successive relic beds, the oldest belonging entirely to the neolithic age. The inhabitants did not yet cultivate the soil, but subsisted chiefly by the chase. The bones of the stag and of the wild boar are extremely plentiful, while those of the ox and the sheep are rare. There are no remains of cereals of any kind, but great stores of hazel nuts were found, together with acorns, some of them adhering to the inside of the pipkins in which they had been roasted for food. The settlement seems to have been burnt, and then after a time rebuilt, the newer relic bed containing numerous flint chips and a solitary bronze axe. Cereals are still absent, although acorns, hazel nuts, and cornel cherries are found. But the pastoral stage had plainly been reached, since the bones of the stag and the wild boar become rare, while those of the ox and the sheep are common.†

These Italian settlements are of especial importance in our inquiry, as Helbig has satisfactorily proved that they were inhabited by the Umbrians, who spoke an Aryan language. We learn, therefore, that when the Aryans first reached Italy they were in the early pastoral stage, and were ignorant of agriculture and of metals.

We gather also that the knowledge of metals came from the South, and not from the East. Settlements exclusively of the stone age are found chiefly north of the Po, while those which contain bronze are mostly further south. It is the same in Switzerland. Settlements of the stone age are most numerous on the Lake of Constance; those of the bronze age on the lakes of Geneva, Bienne, and Neufchâtel.

Our own island formed the last refuge of the theory that Aryan invaders first introduced metal among a neolithic people. As late as 1880 Professor Boyd Dawkins maintained‡ that the round barrow

* Keller, *Lake Dwellings*, p. 363. † *Ibid.*, p. 368.

‡ Dawkins, *Early Man in Britain*, p. 342.

invaders established themselves among the Silurian aborigines of Britain by the aid of the bronze weapons which they brought with them. But even in this, by far the strongest case, further investigation has shown the probability of the overlapping of the ages of bronze and stone. It has already been shown* that bronze is very rarely found in the primary interments of the round barrows, which, at all events in Yorkshire, belong more often to the age of stone than to the age of bronze. Moreover, in Britain, as elsewhere, the oldest bronze weapons are plainly modeled on the type of earlier implements of stone—forms which, being unsuitable for bronze, were soon abandoned.† The tombs which contain bronze weapons of these archaic forms not infrequently contain stones weapons as well. Thus, in a tumulus at Butterwick, in the East Riding of Yorkshire, a bronze celt of the very simplest form, modeled on the pattern of a stone axe, was found, accompanied by a flint knife.‡ In Derbyshire a skeleton was found buried in a hide, with the hair turned inwards, together with an implement of flint and a bronze celt of the plainest stone pattern. No fewer than twenty-seven bronze celts, modeled on the type of stone celts, have been found in England alone,§ and it is possible to trace the gradual development of the forms more suited to the new material from the forms suited to the old.

Hence it seems most probable that the Aryan invasion of Britain took place in the neolithic age.

These conclusions, which are now generally accepted by archæologists, are fatal to the old theory that the Aryans were a comparatively civilized people, who invaded Europe from the East, bringing with them bronze weapons, which enabled them to subdue the aboriginal inhabitants of Europe who were of Basque or Finnish race. The knowledge of metals proceeded from the Mediterranean northwards, being mainly attributable to the gradual extension of Phœnician commerce.

In no part of Europe has it been proved that there was any interruption of continuity between the ages of stone and metal, and there is no evidence whatever to show that the present inhabitants of Europe are not descended from the people of the neolithic age, whose civilization was of a very rudimentary character. Hence the grounds on which a comparatively high degree of culture was assigned to the primitive Aryans will have to be reconsidered. The old conclusions were based on philology; but scholars are now inclined to rank the archæological evidence as of chiefest value, and to assign to philology only a subordinate importance.

A good instance of the way in which the conclusions of philology as to early culture have been corrected by the more trustworthy evidence

* See p. 46, *supra*. † See the engraving on page 82, *infra*.

‡ Greenwell, *British Barrows*, p. 187, Fig. 38. § Evans, *Bronze Implements*, p. 42.

of archæology is supplied by the parallel cases of the horse and the dog. The names of the horse (Sanskrit *açva*, the swift one) and of the dog (Sanskrit *çvan*) are found in almost every Aryan language; and it was formerly supposed that the horse, a native of the steppes of Central Asia, was tamed by the primitive Aryans, and brought with them on their migration to the West.

Now in many of the very early stations, supposed to be palæolithic, such as those at Solutré and Thäyngen, the remains of the horse, associated with those of the reindeer, are extremely abundant, and the animal evidently formed a chief portion of the food of the people; but the horse was manifestly wild. In the oldest of the neolithic Swiss lake dwellings the remains of the horse are absent, or very rare; afterwards they become more common, and in the late bronze age the discovery of bits proves that horses had at last been tamed. Hence it is evident that the common Aryan name for the horse must have referred to the animal as an object of the chase, and has no more significance that the existence of the common names for the wolf and the fox.

With the dog, however, it is different. That the bones of dogs are found in the Danish kitchen middens by itself proves nothing; they may have been eaten like the wolf and the fox, whose bones occur also in the refuse heaps; but we conclude the dog had been domesticated, since those bones of birds and quadrupeds which are eaten by dogs are uniformly absent.* Hence it is evident that the conclusions of philology must be received with hesitation, unless they can be checked by evidence supplied by archæology.

The archæological discoveries of the last thirty years have placed the whole question of early Aryan civilization on a new footing.

In the kitchen middens of Denmark we find the refuse of the feasts of the rudest savages, ignorant of agriculture, subsisting mainly upon shell-fish, and possessing no domesticated animal except the dog.

In the oldest lake dwellings of Germany and Switzerland we find the remains of a people, believed to have been the ancestors of the Celtic race, usually in possession of cattle, but living mainly on the products of the chase. We trace them, during a period which must cover many centuries, at first clad only in skins, then learning to weave mats from the bark of trees, and finally from flax. We find them at first in possession only of the ox, and successively domesticating the goat, the sheep, the pig, and, last of all, the horse. We then see them acquiring by degrees considerable proficiency in agriculture, and passing gradually from the age of stone to the age of bronze, and from the age of bronze to that of iron. In the pile dwellings of Northern Italy we can in like manner trace the same gradual development of civilization, and the passage from the hunting stage through the pas-

* Lubbock, *Prehistoric Times*, p. 240; Lyell, *Antiquity of Man*, p. 15.

toral to the agricultural stage, and from the stone to the bronze age, of a people who are believed to have been the ancestors of the Umbrians, and closely related to the Latin race.

Dr. Schliemann's excavations at Mycenæ and Hissarlik belong to a later period of culture, and disclose the remains of nations unacquainted with iron, but possessed of a civilization splendid in its way, familiar with the uses of bronze, copper, and even of lead, and fabricating in great profusion highly artistic ornaments of gold, ivory, and silver.

It is plain that the civilization which we find in Europe at the beginning of the historic period was gradually evolved during a vast period of time, and was not introduced, cataclysmically, by the immigration of a new race. Just as in geological speculation great diluvial catastrophes have been eliminated and replaced by the action of existing forces operating during enormous periods of time, so the prehistoric archæologists are increasingly disposed to substitute slow progress in culture for the older theories which cut every knot by theories of conquest and invasion.

The most recent results of philological research, limited and corrected as they have now been by archæological discovery, may be briefly summarized. It is believed that the speakers of the primitive Aryan tongue were nomad herdsmen, who had domesticated the dog, who wandered over the plains of Europe in wagons drawn by oxen, who fashioned canoes out of the trunks of trees, but were ignorant of any metal, with the possible exception of native copper. In the summer they lived in huts, built of branches of trees, and thatched with reeds; in winter they dwelt in circular pits dug in the earth, and roofed over with poles, covered with sods of turf, or plastered with the dung of cattle. They were clad in skins sewn together with bone needles; they were acquainted with fire, which they kindled by means of firesticks or pyrites; and they were able to count up to a hundred. If they practiced agriculture, which is doubtful, it must have been of a very primitive kind; but they probably collected and pounded in stone mortars the seeds of some wild cereal—either spelt or barley. The only social institution was marriage; but they were polygamists, and practiced human sacrifice. Whether they ate the bodies of enemies slain in war is doubtful. There were no enclosures, and property consisted in cattle and not in land. They believed in a future life; their religion was shamanistic; they had no idols, and probably no gods properly so-called, but reverenced in some vague way the powers of nature.

This general picture of primitive Aryan culture has now to be substantiated in detail, and the gradual progress in civilization and the arts of life has to be traced from the scanty materials which we possess.

2.—*Metals.*

That the Aryans, before the linguistic separation, were still in the stone age may be inferred from the fact that no Aryan etymology has been found for the word "metal" (μέταλλον), which is regarded by Oppert and Renan as a Semitic loan-word obtained from the Phœnicians. There is no common word in Aryan speech to denote the art of the smith,* and many of the words relating to his trade refer primarily to stone. Each of the Aryan families of speech has an independent name for the smith, a sufficient proof that the arts of smelting and forging metal were later than the linguistic separation. More especially the old theory that the Celts were the vanguard of the Aryan race, who brought with them into Europe the knowledge of metals, falls to the ground, in face of the fact that the Celts have for the smith their own peculiar designation, *goba*, which bears no resemblance to the corresponding words in other Aryan languages, such, for instance, as the Latin *faber*, the Greek χαλκεύς, the Teutonic *smid*, or the Slavonic *vutri*.

The Ural-Altaic races must also have been in the stone age when they came into contact with the Aryans, since the name for the smith was borrowed by the Finns from the Lithuanians, by the Lapps from the Scandinavians, and by the Magyars from the Slaves.

It is a very suggestive fact that the Greek words for the apparatus of the smith—the names for the anvil, the bellows, the tongs, and the furnace—are not related to the corresponding terms in Latin.† Even among the Indians and Iranians, whose linguistic separation was so much later than that of the other Aryan races, these words also differ, with the single exception of the name for the furnace, which may primarily have denoted an oven used for other purposes. Not only are there no common Aryan words for the smith and his tools, but there is no common word for iron, or even for tin, a necessary constituent of bronze. Two metals only, gold and copper, are, as a rule, found in the metallic state. They were known both in Egypt and in Babylonia at the earliest period of which we have any historical cognizance, and in all probability they were the first metals with which the Aryans became acquainted. Native gold is very generally distributed, and native copper is found in Saxony, Hungary, Sweden, Norway, Spain, and Cornwall.

The glittering particles of gold found in the sands of so many rivers must have attracted attention at a very early period. But it is clear that gold was unknown to the undivided Aryans. The Greek χρυσός (Hebrew *chārutz*) being a Semitic loan-word, gold must have been first brought to Hellas by the Phœnicians, not earlier than the

* Schrader, *Urgeschichte*, pp. 221–225.

† Helbig, *Die Italiker in der Poebene*, p. 115.

thirteenth century B.C. We know that the Phœnicians mined for gold at Thasos. The tombs at Spata on Mount Hymettus in Attica, at Thera, at Mycenæ, and at Ialysos in Rhodes, contain objects exhibiting the influence of Phœnician art, and in all of them gold is more or less abundant. These tombs cannot in any case be older than the fourteenth or fifteenth century B.C., as at Ialysos, where the ornament is of the most archaic type, a scarab was found with the cartouche of Amenhotep III.* The probable date of the earliest of these tombs is the thirteenth century B.C. But gold was not known in Italy before the eleventh century B.C., since in the latest pile dwellings of the Emilia, which belong to the bronze age, and which even contain amber obtained by commerce from the Baltic,† neither gold nor silver has been found. In two or three of the Swiss pile dwellings of the bronze age, which survived to a later time than the pile dwellings of Italy, gold has very sparingly been found; in one instance only has a gold ornament been found in a settlement of the neolithic age.‡

That gold was unknown to the Aryans when they entered Italy may also be concluded from the fact that its name, *aurum* in Latin, and *ausum* in Sabine, is a word of Italic origin, denoting the "shining" metal, and related to the word *aurora*, the "shining" dawn.

The story of Brennus casting his sword into the scale to be weighed against Roman gold proves that gold must have been known to the Gauls not later than their invasion of Italy in 390 B.C. It is probable that it was not known to them at any earlier time, since the Celtic name (old Irish *ór*, Cymric *awr*) was borrowed from the Latin; and since the primitive *s* could not have changed to *r* in the Celtic speech, the word must have been borrowed after *ausum* had become *aurum* in Latin, a change which could not have been effected much earlier than the invasion of the Gauls.§

Gold must, however, have reached the Lithuanians, probably in exchange for amber, before it became known to the Celts, since the old Prussian name *ausis* (Lithuanian *auksas*) exhibits the earlier form of the Italic word. The Albanian *âri* proves that the Illyrians obtained their knowledge of gold at a somewhat later time, and also that they obtained it from Italy, and not from Greece.

Gold was known to the Indians before they entered India, and before their separation from the Iranians, since the Sanskrit name, *híranya*, is identical with the Zend *zaranya*, the word being also found in the other branches of the Iranian family—Afghan, Baluchi, and Ossetic. It must have been from the Iranians, probably from Scythic tribes belonging to the Iranian stock, that it penetrated to the Eastern Finns; the Mordwin, Wogul, Ostiak, Wotiak, Zyrianian, and Magyar

* Duncker, *History of Greece*, p. 53; *History of Antiquity*, vol. ii., pp. 63, 72, 73; Newton, *Essays on Archæology*, p. 294.
† Helbig, *Die Italiker in der Poebene*, p. 21.
‡ Keller. *Lake Dwellings*, p. 459.
§ Schrader, *Urgeschichte*, p. 251.

names, *sarni*, *sorni*, or *sirna*, being loan-words from the Iranian. The Teutonic name *gulth* means the "glowing" or "yellow" metal, and the form of the old Slavonic name *zlato* proves that the Slaves must have borrowed the word from the Teutons at an early period. The Western Finns, however, must have obtained it from the Germans, as is shown by the Esthonian name *kuld*, and the Lapp *golle.**

Hence it appears that gold was not in the possession of the undivided Aryans, but was known to the Indians and Iranians before their separation, and possibly also to the undivided Slaves and Teutons.

Its introduction was later than the separation of the Greeks from the Latins, of the Latins from the Celts, and of the Eastern from the Western Finns. The Greeks obtained it from the Phœnicians, and the Celts, Illyrians, and Lithuanians from the people of Italy.

It was unknown to the Greeks before the thirteenth century, when the Phœnicians reached the coasts of Hellas; it was unknown in Italy in the eleventh century, when the Etruscan invaders destroyed the Umbrian settlements; but it had probably reached Italy as early as the ninth century, when the Greeks and Phœnicians had established themselves at Cumæ and Cære. It reached the Baltic before the fifth century, and Gaul and Illyria in the fourth. In Switzerland bronze was plentiful while gold was still unknown.

The discovery of copper must have preceded that of gold by many centuries. Not only the lake dwellings of Switzerland and Italy, but the Babylonian and Egyptian monuments prove that copper was the earliest metal to be discovered.

There is one Aryan word whose wide diffusion has to be explained, and which has been confidently adduced to prove that the undivided Aryans were acquainted with either bronze or copper.† This is the Sanskrit *ayas*, which corresponds with the Latin *æs*, the Gothic *aiz*, the German *erz*, and the English *ore*. The Latin *æs* denoted copper as well as bronze, the Gothic *aiz* meant brass or bronze, while the Sanskrit *ayas* is believed to have originally denoted copper, then metal in general, and afterwards iron. If copper was, as seems probable, the first metal to be discovered, it is easy to see that the name might have been generalized to denote metal, and then specialized to denote either iron, brass, or bronze. In any case the original meaning could not have been iron, since, for the linguistic and archæological reasons already stated, it is certain that the primitive Aryans had not reached the iron age.

That the metal designated by *ayas* or *æs* was copper and not bronze is also indicated by the fact that there is no common Aryan name for tin, which is a necessary constituent of bronze. The Greek name κασσίτερος is borrowed from the Semitic (Assyrian *kasazitirra*), which again is derived from the Accadian *id-kasduru*. Two small

* See Schrader, *Urgeschichte*, pp. 243-254. † *Ibid.*, p. 267.

bars of tin have been found in Swiss pile dwellings of the bronze age, and also at Hallstadt, but tin has not been found at Hissarlik.

Lenormant has drawn attention to a curious fact, very difficult to explain. The oldest known word for copper is the Accadian *urud*, or *urudu*. Copper is *urraida* in Basque, *rauta* denotes iron in Finnic, and *ruda* means metal in old Slavonic, while *rôd* is brass in Beluchi, and *dru* is copper in the Semitic Babylonian. It is difficult to suppose that these resemblances can be merely accidental; and yet there are the strongest reasons for believing that both the Finns and the Basques were in the stone age when they came into contact with the Aryans, since the Basque word for knife primarily means a stone, and the Finnic names for smith are Aryan loan-words.

If the word *ayas*, *æs*, or *aiz*, is primitive, and if it meant copper, it is difficult to explain the entire absence of metal from the early Aryan settlements.

Three solutions are possible. It may have been a commercial loan-word, which is improbable. It may originally have denoted, not smelted metal, but ore—probably the lumps of iron pyrites found not uncommonly in neolithic tombs,* and which seem to have been used for procuring fire by striking them with flint, and may afterwards have come to denote the metal smelted out of such heavy stones. A third explanation finds favor with Dr. Schrader. He is inclined to consider the Latin *monile*, a word which reappears in the Indo-Iranian, Greek, Teutonic, and Slavonic languages, as an indication that copper rings, rudely beaten out with stone hammers from lumps of native copper, or obtained by barter from the East, may have been used as ornaments by the undivided Aryans.

The archæological evidence from the Swiss lake dwellings and elsewhere lends as yet no support to this theory, more especially as the earliest bronze celts—all those, for instance, found in the pile dwellings of Northern Italy—are cast and not hammered.† It is, however, possible that such copper rings were so rare and precious, being obtained only by barter from the distant East, that they do not happen to have been found.

At all events the Greeks, who were the most advanced in culture of the Aryan nations, seem to have been unacquainted with copper when they were first visited by Phœnician mariners. The Greek name for copper, χαλκός, is isolated in the Aryan languages. It has been supposed either to be a Semitic loan-word,‡ or, just as the Latin *æs cuprium*, the source of our word *copper*, was derived from the name of the island of Cyprus, so the Greek word χαλκός, copper, may have been derived from the Eubœan city of Chalcis, which itself may have taken

* Greenwell, *British Barrows*, p. 266.

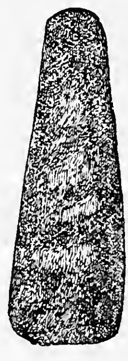
† Helbig, *Die Italiker in der Poebene*, p. 19.

‡ Cf. Hebrew *chālāk*, smooth. Wharton, *Etyma Græca*, p. 132.

its name from the *κάλχη*, or purple murex, in quest of which the Phœnicians first resorted to the coast.* In either case the Greeks seem to have been ignorant of copper when the Phœnicians first reached their coasts.

That a copper age preceded the bronze age, and that *ayas* or *æs* originally denoted copper rather than bronze, is also indicated by the fact that some of the oldest metal celts, which are imitations of the earlier stone celts, are of copper, not of bronze. In the museum at Berlin there is a copper celt, found in an Etruscan tomb, which is of the precise shape of an ordinary stone celt,† and even appears to have been cast in a mold formed by means of a stone implement of the same type. Celts of the simple flat stone type, without flanges, either of pure copper or of copper with so small a percentage of bronze as to be almost indistinguishable from copper, were found by Dr. Schliemann at Hissarlik, and by General di Cesnola in very early tombs in Cyprus. Flat celts of copper, of the stone type, have also been found in India, Austria, Hungary, France, and Italy.‡

In the pile dwelling at Maurach on the Lake of Constance, which belongs to the stone age, among fifty stone implements the only object of metal was a broken copper axe.§ At Sipplingen, also on the Lake of Constance, no bronze implements were found, but there were 350 stone axes, and one of copper, very simple in form, resembling the stone axes.‖ And at Gerlafingen, also a settlement of the stone age, on the Lake of Bienne, were found two chisels of pure copper of the simplest stone type.¶



COPPER CELT FROM SIPPLINGEN.

The figure represents the copper celt of the stone type from the lake dwelling at Sipplingen.

The recent explorations of the MM. Siret among the prehistoric tombs in the south-east of Spain have clearly revealed the existence of a copper age, intermediate between the stone and bronze epochs. Eighty axes of polished stone, and seventy flat copper axes of the stone type, were discovered in these tombs.

Dr. Evans explains the scarcity of copper implements by the supposition that on the discovery of bronze the copper implements were melted down and recast in bronze. But while in many parts of the Continent there is sufficient evidence that the bronze age was preceded by a copper age, there is no such evidence in Britain. It is therefore probable that bronze, introduced by traders from Gaul, was the first metal known in our island. Even as late as

* Schrader, *Urgeschichte*, p. 278. † Evans, *Ancient Bronze Implements*, p. 39.

‡ Evans, *Ancient Bronze Implements*, p. 40

§ Keller, *Lake Dwellings*, vol. i., p. 121.

‖ *Ibid.*, p. 126, plate xxix. ¶ *Ibid.*, p. 452.

Cæsar's time the Britons obtained their bronze by commerce from the Continent. The type of the British bronze weapons differs both from the Scandinavian and the Hungarian types, but agrees with the type characteristic of the north of France. The types in the Swiss lake dwellings agree with those of Northern Italy and the South of France.* Hence we conclude that the knowledge of metals penetrated gradually to the north from the Mediterranean lands which were visited by Phœnician ships.

Since silver rarely occurs in a native state, and is a difficult metal to reduce, we cannot be surprised to find that it was unknown to the primitive Aryans. The Celtic and Illyrian names were borrowed from the Latin, the Teutonic and Slavonic from the Semitic, while the Latin, Greek, and Sanskrit names were independent formations. It was probably unknown to the Celts before they invaded Italy, as the Celtic name (old Irish *argat*) is an Italic loan-word (Latin *argentum*, Oscan *aragetud*). This word is from the Aryan root *arg*, and means the "white" or "bright" metal. In Greek, Sanskrit, and Zend the name is formed from the same obvious root, but with a different suffix, showing an independent invention of the word. The two earliest sources of silver seem to have been Armenia and Spain. In the south-east of Spain, where silver occurs in a native state, ornaments of this metal have been found in tombs of the early bronze age. It seems to have become known to the Greeks, probably through Phœnician commerce, shortly before the Homeric period. Dr. Schliemann found silver in the tombs at Mycenæ, which are of the Phœnician style of architecture, and he discovered electrum, a natural alloy of gold and silver, in the second and third strata at Hissarlik. Silver has not been found in the oldest Phœnician tombs in Greece, which may date from the twelfth century B.C., nor as yet in the Italian pile dwellings of the bronze age.† But in some of the latest of the Swiss pile dwellings of the iron or late bronze age, probably dating from the fourth or third century B.C., three or four silver ornaments have been discovered. In the time of Herodotus silver was unknown to the nomad Aryan tribes north of the Euxine; but the northern name (Gothic *silubr*), which is common to Lithuanians, Slaves, and Teutons, is believed to be a loan-word from the Semitic (Assyrian *sarpu*)—an indication that the Baltic nations first obtained it by the trade route of the Dnieper from the region of the Euxine.‡

Hence we gather that it reached the Greeks earlier than the tenth century, and the Celts not before the fifth.

There can be no question that the age of iron was later than the age of bronze. The Greek words χαλκεύς, a smith, and χαλκεών, a

* Evans, *Ancient Bronze Implements*, pp. 482-484.

† Helbig, *Die Italiker in der Poebene*, p. 21.

‡ Schrader, *Urgeschichte*, pp. 256-265.

smithy, are derived from the name of copper, not of iron. The pile dwellings in the valley of the Po belong to the ages of stone and bronze, but afford no trace of iron. Hence we obtain an approximate limit for the introduction of iron into Italy. Helbig has shown good reasons for believing that these settlements must be assigned to the Umbrians, an Aryan people, and that they were destroyed at the time of the Etruscan conquest of Northern Italy. Now, according to a tradition preserved by Varro, the Etruscan era began in 1044 B.C., a date which agrees roughly with that assigned to the Thessalian and Dorian invasions of Greece, with which it was probably connected, while the Dorian inroad led to the Mœsian settlements of Æolian, Achæan, and Ionian tribes, dim memories of which lie at the base of the Homeric epos. These events clearly occurred towards the close of the bronze age. Iron was unknown to the Umbrians of Northern Italy at the time of the Etruscan inroad. The third or burnt city at Hissarlik, which Dr. Schliemann identifies with the Homeric Troy, was also in the bronze age; and in none of the five prehistoric cities at Hissarlik are there any vestiges of iron. Iron, however, plays a considerable part in the *Iliad*—another proof, if proof were wanted, of the comparatively late date of the Homeric poems, and also affording a rude but valuable indication of the limits of date between which iron must have become known to the Greeks. Again, the great tombs discovered by Dr. Schliemann at Mycenæ must be assigned to that earlier period of Greek civilization which was overwhelmed and destroyed by the rude Dorian conquerors. In the excavations at Mycenæ iron knives were found, but only in certain late deposits, which are assigned by Dr. Schliemann to the fifth century B.C. Hence three concurrent lines of evidence tend to show that iron was unknown in Argos, Mœsia, and Northern Italy in the twelfth or eleventh century B.C.

In the time of Homer the age of iron was just commencing in Greece. He constantly mentions bronze weapons, while iron is still a rare and precious metal. Hesiod, *circa* 850 B.C., refers to a time when bronze had not yet been superseded by iron, which had already become commoner and cheaper than copper, as was the case in Assyria in the eighth century B.C. Homer mentions seven metals—gold, silver, lead, tin, copper, bronze, and iron. He also mentions the smith, the anvil, the hammer, and the pincers. Iron was at first chiefly used for swords, as Hesiod gives Heracles a sword of iron, but even down to the time of Pindar (*circa* 470 B.C.) bronze was still used for certain weapons, as he repeatedly mentions spear-heads and axes of bronze.

Another indication of date is afforded by the Italic name of iron. The Latin word *ferrum*, which points to an earlier *fersum*, is isolated in Aryan speech, and is believed to be a loan-word from the Semitic *bar(e)zum*, an indication that the metal was first introduced into Italy by Phœnician traders. The Phœnicians must have reached Sicily about the twelfth century,* and soon afterwards established a trading station in Central Italy, probably at Cære.

Like the Latin *ferrum*, the Greek name of iron, *σίδηρος*, is isolated in the Aryan languages. Dr. Evans compares this with the Latin *sidera*, and suggests a reference to meteoric iron.† But as Semitic and Greek tradition both point to the land of the Tibareni on the shores of the Euxine as the earliest source of iron, Dr. Schrader is of opinion that the Greek name may be a loan-word from one of the languages of Asia Minor.

In any case the knowledge of iron must have been derived from the East. It is denoted in the Semitic languages by a word borrowed from the Accadian. In Egypt it was known as early as the twelfth dynasty. But the knowledge of copper must have preceded that of iron, since the sign for copper is used as a determinative or generic sign for the word *men*, iron, while the copper mines in the Peninsula of Sinai were worked by the Egyptians as early as the second or third dynasty, and by the Babylonians probably at the time of the sixth.

Another curious indication of the relative priority of iron and copper, as well as of the locality where iron was first smelted in Northern Europe, is afforded by the history of our own word "iron." In Gothic, as we have seen, *aiz* meant brass or bronze, while iron is denoted by the derived word *eisarn*. But the suffix *arn* is distinctively Celtic, and hence the Teutons must have derived their knowledge of iron from their Celtic neighbors. Out of *ais*, "bronze," the Celts must have constructed the derivative *aisarn*, and then, in accordance with a well-known euphonic law of the Celtic languages, the *s* fell out between two vowels, leaving for iron the name *iarn* in old Irish, and *haiarn* in old Welsh. But before this loss of the sibilant, the Celtic word must have found its way into Teutonic speech, iron being denoted by *eisarn* in Gothic, *isern* in Anglo-Saxon, *isarn* in old Norse, *eisen* in German, and *iron* in English.‡

The evolution of the Teutonic and Celtic names for iron must have taken place in some region where iron ores were abundant, and where Celts and Teutons were in approximate contact, and also not far from the primitive seat of the Goths on the southern shores of the Baltic. Hallstadt, where iron has been found in the prehistoric salt-workings of a Celtic people, is probably too far to the south; but all the conditions of the problem are found united in the region of the Erzgebirge, which divide Bohemia from Saxony. As the name implies, these mountains are rich in metallic wealth, while down to the

* Duncker, *History of Antiquity*, vol. ii., p. 87.

† Evans, *Ancient Stone Implements*, p. 6.

‡ Schrader, *Urgeschichte*, p. 293.

first century B. C. they formed the ethnic frontier between Celts and Teutons. Here most probably we may locate the earliest iron manufacture in Northern and Western Europe. This must, however, have been as early as the fifth century B. C., as the Gauls possessed iron swords when they invaded Italy.

The Slavonic and Lithuanian name for iron is also derived from a word denoting copper. The Slavo-Lithuanian name for iron is *gelezis*, and the probable source of this word is the Greek χαλκός, copper or bronze. The knowledge of metals must have reached them from the Greek trading colonies of the Euxine, probably about the sixth century B. C. In the time of Herodotus the Scythians had no bronze, but the Massagetæ had gold and copper, but neither iron nor silver.*

There is no common Aryan name for lead. The knowledge of lead must, however, have preceded that of iron, since lead was abundant at Mycenæ, which was in the bronze period, and lead occurs in all the five prehistoric strata at Hissarlik, in none of which any iron has been found.

As for salt, Benfey, Schleicher, and Max Müller have asserted, on linguistic grounds, that it was known to the undivided Aryans. The name runs through the European languages, but its existence in Indo-Iranian is disputed. The word *sara* means "water" in Sanskrit, but Hehn maintained that this is no sufficient proof that the Indians were acquainted with salt. Curtius and Benfey observed that the Sanskrit word is employed in the sense of "briny," to which Bohtlingk replied that this signification does not appear at any earlier date than in a Sanskrit dictionary of the twelfth century A. D., and therefore proves nothing.†

As for any absolute dates for the introduction of the various metals, the calculations that have been made can be regarded as only approximate. Besides, while one nation was in the stone age, another may have been acquainted with bronze, and a third with iron. Besides, the introduction of each metal was very gradual. Arrows continued to be tipped with flint or bone long after bronze was used for other weapons. Arrows are more liable to be lost, and therefore flint was preferred when metal was costly. Flint arrow-heads are frequently found in barrows, together with bronze celts.‡

From the gradual improvement in the types of the bronze implements, Dr. Evans thinks that the bronze age must have lasted for many centuries—eight or even ten; but this estimate would have to be extended if M. Morlot is right in assigning certain bronze implements found in the cone of the Tinière, near the head of the Lake of Geneva, to about the year 1900 B. C.

* Evans, *Ancient Bronze Implements*, p. 17.

† Schrader, *Urgeschichte*, p. 56.

‡ Evans, *Ancient Stone Implements*, 328, 353.

It is thought that gold and copper may have been known to the Indo-Iranians as early as 2000 B.C.* The Greeks were probably acquainted with bronze before the thirteenth century B.C., with gold as early as the twelfth, with silver not before the eleventh, and with iron before the ninth century.

In Italy bronze had certainly been known for a considerable period before the eleventh century, possibly as early as the ninth. Gold was not known in the eleventh century, and iron not before the tenth.

Dr. Evans places the beginning of the bronze period in Britain between 1400 and 1200 B. C., and Sir John Lubbock between 1500 and 1200 B.C.—estimates which give us a minimum date† for the appearance of the round barrow Aryan-speaking people in our island. Dr. Evans thinks iron swords were used in Gaul in the fourth or fifth century B.C., and in the south of Britain a little later. He considers that, in the third or second century B.C., bronze had practically fallen into disuse for cutting implements. ‡

Iron probably became known to the Slaves and Teutons in the sixth or fifth century B C., and to the Celtic peoples of Central Europe somewhat earlier. In the time of Pausanias, 174 A.D., we are told that iron was unknown to the Sarmatians.

3.—*Weapons.*

The names of weapons, though they differ as a rule in the Aryan languages, occasionally afford proof of a descent from the stone period. Thus the old Norse *sax*, the old High German *sahs*, the Anglo-Saxon *seax*, a sword, is plainly related to the Latin *saxum*, a stone, and the Iranian *asti*, arrows, is related to the Latin *os*, a bone, and proves that the primitive arrows were tipped with bone and not with bronze or iron. Even during the late bronze period in Europe, the arrow-heads were of flint or bone, bronze being too valuable a metal to be shot away and lost.

It is noteworthy that while the European words connected with pastoral and agricultural pursuits agree to a considerable extent, those for weapons are mostly different. The Greek and Latin designations for bow, arrow, sword, spear, shield, helmet, and armor are unconnected, while on the other hand the Greek words for bow-string, arrow, spear, sling-tone, battle-axe, and shield can be traced in Sanskrit. One Italic word, *ensis*, which originally denoted a knife—doubtless of stone—rather than a sword, is the only Latin name for a weapon which can be traced in the Indo-Iranian tongues. The *ensis* was a stabbing weapon, the cutting sword being designated in Latin

* Duncker, *History of Antiquity*, vol. iv., p. 30; Evans. *Anicent Bronze Implements*, pp. 471, 472.

† See p. 128, *supra*.

‡ Evans, *Ancient Bronze Implements*, pp 471, 472.

by the word *gladius*, which is believed to be a loan-word from the Celtic (old Irish, *claideb*; Cornish, *cledyf*). The legend of Brennus makes it probable that the *gladius* became known in Italy after the invasion of the Gauls. It was much the same in Greece. No trace of a sword has been found in any of the prehistoric strata at Hissarlik, which is itself a proof of the late date of the *Iliad.* The Homeric name ξίφος being a Semitic loan-word (cf. the Arabic *seifun*) is an indication that the Greek sword was obtained from the Phœnicians, as the Roman sword was from the Gauls. The Roman *lorica* was made of leathern thongs, and the shield, *scutum*, was, as the name implies, originally an ox-hide. The Greek names prove that the primitive shields were made of hydes or wicker-work, and that the helmet was at first merely a cap of dogskin. The names of weapons common to Zend and Sanskrit prove that the Indo-Iranians, before their separation, must have been acquainted with the bow, the spear, the javelin, the sword, the knife, the battle-axe, and the club, but only with one defensive weapon, the shield. The terms for defensive armor, mail and helmet, are later than the separation of Indians and Iranians.

The bow, a favorite weapon with the Southern and Eastern Aryans, seems to have been of late introduction in the North, the German *pfeil*, arrow, being a loan-word from the Latin *pilum*, while the old Irish *saiget*, arrow, is a loan-word from the Latin *sagitta.*

The chief Northern weapon seems to have been the stone axe or hammer. So late as the thirteenth century Sir William Wallace went into battle against the English armed with a celt or stone axe; and weapons of stone seem to have been used by Harold's armed peasants at the battle of Hastings.*

4.—*Cattle.*

The sepulchral caverns aud dolmens of France and Belgium prove that, at the beginning of the neolithic age, the inhabitants of Europe were nomad hunters, sheltering themselves in caves, subsisting on the products of the chase, and possessed of no domesticated animal. In the kitchen middens of Denmark we find that the first onward step in progress had been made, and the dog had been trained as an assistant in the chase. The oldest lake dwellings of Southern Germany exhibit a further stage in culture. The people had fixed dwellings constructed with considerable skill, and we can trace their gradual progress from the life of the hunter to that of the herdsman.

The wild horse, which roamed in immense herds over the plains of Europe, and had formed the chief food of the people who sheltered themselves in the caverns at Solutré, Auvernier, Salève, and Thäyngen,

* Helbig, *Die Italiker in der Poebene*, p. 42. See, however, Evans, *Ancient Stone Implements*, p. 132.

had become scarce;* but the wisent, or bison, and the huge wild ox which had been a contemporary of the mammoth and the rhinoceros, were still abundant; gradually disappearing, however, with the introduction of improved weapons. In the earliest lake settlements the bones of the urus, the marsh cow, and the marsh hog abound.† In Austria and Bavaria the stag and the wild boar seem at first to have constituted the chief food of the people.‡ But as the population increased, and the wild animals became scarce or more difficult of approach, we can trace the neolithic hunters gradually passing into the pastoral stage, and finally acquiring no inconsiderable skill in agriculture.

One of the oldest lake dwellings is that at Schussenried, on the Feder See in Würtemberg, which, from the character of the flint implements, has been thought to be coeval with the Danish kitchen middens.§ Here we find the earliest trace of any pastoral people, though the chase still constituted the chief means of support. This is shown by the fact that of the bones found in the refuse heaps those of the stag amount to about three-fifths of the whole, and those of the marsh hog are very abundant, while those of domesticated animals are extremely scarce, only just sufficient to make it possible to determine their existence. All that have been found are the remains of one sheep, of two dogs, and of three oxen of the kind called the Celtic shorthorn—a species whose bones have also been discovered in dolmens of the neolithic age.

The Celto-Latin race, to which the lake settlements in Southern Germany must be assigned, seems then to have advanced southward and occupied the fertile plains of Western Switzerland. In the oldest of the Swiss lake dwellings, such as that at Wauwyl, in the Canton of Lucerne, though the bones of wild animals still predominate, the ox has become common; but the sheep is still extremely scarce, the remains of only one specimen having been discovered. As we come down to the later neolithic pile dwellings the remains of wild animals become scarce, the sheep becomes more common, the goat makes its appearance, and finally, at the close of the stone age, the pig has to be added to the list of domesticated animals. At Nidau, which belongs to the bronze age, the pig becomes abundant. At the settlement of Möringen, which is of the late bronze or early iron age, we have evidence that the horse had been tamed. In the pile dwellings of Northern Italy, which come down to the bronze age, the horse and pig appear, but the ass and the domestic fowl are still unknown.

The conclusions of the science of linguistic palæontology agree substantially with those of prehistoric archæology. The evidence of language proves that, before the linguistic separation had become com-

* Keller, *Lake Dwellings*, p. 552. † *Ibid.*, p. 538. ‡ *Ibid.*, pp. 587, 592, 615.

§ Keller, *Lake Dwellings*, p. 589.

plete, the Aryan-speaking peoples had entered on the pastoral stage, and had domesticated the dog, the cow, and the sheep. The names of these animals may be traced to Aryan roots, an indication that the Aryans developed the pastoral life without the influence of any alien civilization. That the undivided Aryans were a neolithic people, in the pastoral rather than the agricultural stage, and were herdsmen rather than shepherds, is shown by the fact that so large a number of the words common to every branch of Aryan speech refer to the cow, the terms relating to agriculture, weapons, metals, and religion having, as a rule, a more limited range.

The wealth of these primitive people consisted almost wholly of their herds. This is indicated by the fact that the collective name for cattle, which appears in Latin, Sanskrit, Zend, Lithuanian, and German, denoting originally that which has been tied up,* has been the source of numerous words denoting property and money, such as *peculium* and *pecunia* in Latin, and our *fee*, which is the Anglo-Saxon *feoh*, meaning both property and cattle, and identical with the German *vieh*, a cow. The ox, which is figured on early Roman coins, may be a survival from the time when the ox was the standard of value and the medium of exchange, and the coin may probably have at first represented the value of the animal. This is supported by the fact that in the Homeric age the measure of value was the ox. The arms of Diomed are worth nine oxen; those of Glaucus are worth a hundred. The tripod, which was the first prize for the wrestlers, was worth twelve oxen. One female slave is valued at twenty oxen, another at four.†

Professor Max Müller‡ has brought together some curious linguistic evidence as to the supreme importance of cattle among the Vedic Indians. The Sanskrit word *gopa*, a king, must have meant originally only a cow-herd; it then came to mean the head of a cowpen, and lastly the chief of a tribe. The word *goshtha*, which denoted primarily the cowpen, came to mean an assembly; *gotra* passed through the successive meanings of the inclosure for the cows, then the herd itself, and lastly a family, tribe, or race. The word *goshu-yúdh*, used in the Veda to denote a warrior, means etymologically "fighting for the cows," and *gávishti*, "strife," is literally a "striving for cows," which recalls the source of the quarrel between the herdsmen of Lot and Abraham.

It is also curious to note, as a further indication that the primitive Aryans were a pastoral people, that the only colors whose names belong to this primitive period are the usual colors of cows. Thus the word for red runs through all the Aryan languages—Sanskrit, Greek,

* Latin, *pecus*; Sanskrit, *paçu*; Zend, *pasu*; Lithuanian, *pekus*; Gothic, *faihu*; German, *vieh*—all from the root *pak*, to take, bind fast, or tie up.

† Ridgeway, "Metrological Notes," in *Journal of Hellenic Studies*; Gladstone, *Juventus Mundi*, p. 534.

‡ Max Müller, *Essays*, vol. i., pp. 326–328.

Latin, Slavonic, Celtic, and Teutonic; but common words for blue and green are wanting, the terms we possess for these colors being of later origin. This fact has given rise to much futile discussion, and even to the singular theory that the primitive Aryans were color-blind to the hues of the grass and of the sky. It is simpler to suppose that they had not advanced beyond the pastoral stage, and at first only required, and consequently only possessed, the words required to distinguish the colors of their cows. This explanation is supported by the fact that the only words for colors among some African races are those which designate the colors of cattle and game—black, gray, white, yellow, and red. The same fact confronts us in the Finnic languages. The word for color is *karva*, which etymologically means "hair," and loan-words are employed to denote green and blue. That there is no common Aryan word for the season of harvest* is another indication that the undivided Aryans had not reached the agricultural stage.

The dog, the friend and servant of the hunter as well as of the herdsman, was the first animal to be tamed, his remains, as we have seen, being found in the Danish kitchen middens, from which all other domesticated animals are absent. His name probably means "the prolific one," and is found in every branch of Aryan speech.†

The name of the "cow" is also common to all the Aryan languages—Sanskrit, Zend, Armenian, Greek, Latin, Celtic, Teutonic, and Slavonic. The name of the "steer" is almost as widely diffused; that of the "ox" occurs in Sanskrit, Celtic, and Teutonic. The Latin *vacca* may be traced in Sanskrit, and *vitulus* in Sanskrit and Greek.

As for the sheep, the Latin name *ovis*, reappears in the Greek, Sanskrit, Teutonic, Lithuanian, Slavonic, and Celtic languages. The goat, which is not found in the earliest lake dwellings, was tamed at a later period. The Greek name, *αἴξ*, extends only to Sanskrit, Armenian, and Lithuanian, while the Latin *caper* is also found in Celtic and Teutonic. The evidence of the Swiss pile dwellings is conclusive that the "jumper" received its name while it was still only an animal of the chase.‡

The name of the sow is less widely extended, the Sanskrit word denoting only the wild boar. In the oldest Swiss lake dwellings the bones of the wild marsh hog are found abundantly, but the animal seems to have been domesticated at a later time than the dog, the cow, the sheep and the goat. The linguistic evidence also indicates that the domestication of the pig took place after the separation of the Aryan peoples. The pig belongs essentially to the fixed agricul-

*See p. 95, *infra*.

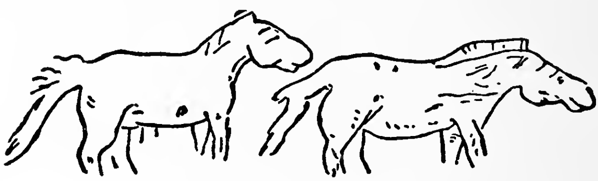
† Sanskrit, *çvan;* Zend, *spâ;* Lithuanian, *szu;* old Irish, *cu;* Greek, *κύων;* Latin, *canis;* German, *hun-d.*

‡ Hehn, *Wanderings of Plants and Animals*, p. 462.

tural stage. The cow and the sheep would more readily share the life of nomad herdsmen than the pig, whose winter food would be difficult to provide, and who is not so easily herded or driven from place to place as the cow. In some of the Swiss pile dwellings of the bronze age, where the domesticated pig first becomes common, stores of acorns have been found, which were doubtless collected in the autumn as winter provender for the swine.

The comparatively late date of the domestication of the pig is also indicated by the fact that tame swine were unknown to the Accadians or to the proto-Semites. In literature they first appear in Homer, not being mentioned either in the Veda or the Avesta.

The case of the horse is of great interest. The Latin name, *equus*, is common to all the Aryan languages ; and it was formerly supposed that the Aryan immigrants brought the animal with them into Europe from its Asiatic home. But recent archæological discoveries have overthrown these conclusions, and have shown that the common name must refer to the wild horse which roamed in immense herds over Europe, and formed the chief food of the palæolithic hunters. In some of the caverns in France the remains of the horse are more



HORSES FROM LA MADELAINE.

abundant than those of any other animal, more even than those of the wild ox. Thus at Solutré, near Maçon, the bones of horses, which had formed the food of the inhabitants of this station, form a deposit nearly 10 feet in depth and more than 300 feet in length, the number of skeletons represented being estimated at from 20,000 to 40,000. This primitive horse was a diminutive animal, not much larger than an ass, standing about 13 hands high, the largest specimens not exceeding 14 hands. But the head was of disproportionate size, and the teeth were very powerful. He resembles the tarpan or wild horse of the Caspian steppes. A spirited representation of two of these wild horses is engraved on an antler found at the station of La Madelaine in the Department of the Dordogne.

The deposits in the caves at the foot of Monte Pellegrino, near Palermo, also afford evidence that the wild horse formed the chief sustenance of the early inhabitants of Sicily. Herds of wild horses were probably chased along the narrow valleys into pit-falls, or over the cliffs, and so destroyed. With the introduction of improved weapons of bone and horn the wild horse became less abundant, but he had a wide range over France, Belgium, Germany, Switzerland, and England.

In the neolithic age the wild horse ranged over the plains in the west of Switzerland, and formed an element in the food of the inhabitants of the earlier lake dwellings. He appears at first to have been only semi-domesticated. For the sake of their flesh and milk, herds of half-wild horses may have been driven along by the Aryan herdsmen migrating in search of pasture, as is now done by the Tartars of the Asiatic steppes.

The horse as a domesticated animal was not known to the Accadians before the Semitic conquest of Babylonia, or to the Semites before the linguistic separation of the Semitic family, and it does not appear on the Egyptian monuments till the time of the New Empire. This was after the conquest of Egypt by the Hyksos, by whom the horse was doubtless introduced from Central Asia. It was well known to the Hittites (Kheta) and to the undivided Turko-Tartaric race—an indication that it was first tamed in Central Asia. In the Swiss lake dwellings of the stone and early bronze ages, bones and teeth of horses, which were doubtless used for food, have been scantily found; but it is only at Möringen and Auvernier, which belong to the latest bronze age, that we find horses' bits of stag's horn and bronze. These bits are only 3½ inches* wide, and could now hardly be used for a child's pony. I have made some measurements for the purpose of ascertaining the size of the horses for which the bits of the bronze age would be suitable. A cob of 13¼ hands required a bit 4¼ inches in width, and a Shetland pony of 11¾ hands required a bit 3¾ inches in width, and shoes 3 inches wide. Modern bits for horses vary in width from 4½ to 7 inches, and I am informed that bits of the size of those found in the Swiss lake dwellings are now only used for donkeys.

The earliest horse-shoes come from the lake settlement at Paladru, in Dauphiné, which belongs to the late iron age, and is probably post-Roman. The shoes are from 3½ to 4 inches in width, a proof that the horses must have been very small. The late bronze settlements of Northern Italy, which may date from the eleventh century B. C., prove that the horse had then been tamed.

For a long period after the horse was tamed the more manageable ox still continued to be used as the beast of burden and the beast of draught, the horse being reserved for chariots of war, as was the case among the Egyptians, the Assyrians, and the Hittites, and also for chariot races and triumphal processions, as among the Etruscans and the Greeks. It is curious to notice at how late a period men first ventured to mount the "swift one." In ancient Egypt, as now, the ass was exclusively used for riding. There is nothing in the Veda to show that the art of riding was practiced. We first meet with a notice

* Keller, *Lake Dwellings*, pp. 173, 243.

of it in the Avesta, an indication that the art was first acquired by the Iranian Aryans from the contiguous Tatar tribes. The words relating to equitation are different in the Zend, Greek, Latin, and Teutonic languages. Among the Greeks of the Homeric age horses were harnessed to chariots for war or races, and a bare-backed horse might occasionally be mounted, but there was no riding in our sense of the word.*

The cut, taken from a terra-cotta figure found by General di Cesnola in Cyprus, is probably the earliest representation we possess of a man on horseback. Some later figures show that the horse was first ridden with a halter rather than with a bit.

The remains of the ass have not been found in the Swiss lake dwellings, or even in the Italic settlements of the bronze age. It must have been introduced into Europe from the East at a comparatively late period. The Celtic, Teutonic, and Slavonic names are obviously loan-words from the Latin, and the Latin name is a Semitic loan-word from the Phœnician. The European and Asiatic Aryan names for the ass are wholly different, but it was known to the Indo-Iranians before their separation. As the native home of the wild ass is in Central Asia, and more especially in the steppes of the Aral-Caspian plain, the fact that the primitive Aryans were not acquainted with this useful beast of burden seems as conclusive an argument against the Asiatic origin of the Aryans as the fact that they were acquainted with the beech, a tree confined to Europe.

The case of the camel is quite as strong. There is not the faintest indication that it was known to the undivided Aryans; but if they had migrated from Central Asia they must have been acquainted with this animal, which was known to the undivided Semites, and also to the primitive Turko-Tartaric race. It was known also to the united Indo-Iranians, whose home, before their separation, was in Bactria, or Eastern Iran. The name of the camel is a Semitic loan-word, and that it was unknown at first to the Slaves appears from their having transferred to it the name of the elephant, as is shown by the old Slavonic word *veliblandu*, a camel.

Neither in the pile dwellings of Switzerland or Northern Italy are there any traces of domestic fowls, which first make their appearance in the Avesta, and spread from Persia to Greece in post-Homeric times, probably about the sixth century B.C.† The goose had been domesticated by the Greeks before the Homeric age, but not when the Iranians and Indians separated. The Aryan names of the goose, the pigeon, and the duck must have been given to these birds while still wild. Neither the Semites nor the Finns possessed poultry before the respective linguistic separations. The nomad herdsman, with the

* Hehn, *Wanderings of Plants and Animals*, p. 51.

† *Ibid.*, p. 243.

aid of his dog and his flint-pointed spear, could drive cattle from place to place, and protect them against beasts of prey; but poultry cannot so easily be driven, and well-fenced enclosures would be necessary to protect them against their natural enemies, the fox, the weasel, the eagle, and the hawk.*

In the foregoing discussion it has been assumed that the inhabitants of the Swiss and Italian pile dwellings were Aryans. Helbig has proved that the Italian pile dwellings must be Umbrian, since they are earlier than the Celtic and Etruscan invasions, and exhibit a state of culture far in advance of that possessed at a considerably later period by the Ligurians. But if the Italic settlements are Umbrian, the Swiss settlements must be Celtic or Helvetic. Dahn has maintained that the inhabitants of the Swiss lake dwellings were of Finnic race, but this conclusion Schrader rejects on the ground that the Eastern and Western Finns, before their separation, were acquainted with the dog, the cow, and the horse, but not with the sheep and the goat; whereas the oldest lacustrine people of Switzerland had tamed the sheep and possibly the goat, but not the horse.

Moreover, as has already been shown, the Swiss pile dwellings were inhabited continuously till the iron age, and some of them even down to the Roman period,† when we know that the country was inhabited by a Celtic-speaking people. From this fact, taken together with the resemblance of the Helvetic skull to that of the Romans and the round barrow people of Britain, there can be little doubt that we are dealing with a civilization which must be classed as Aryan, and not Finnic.

5.—*Husbandry.*

The fact that the German *herbst*, autumn, means the "harvest" time may remind us that among an agricultural people the time for the ingathering of the crops is the most important as well as the most festive season of the year. But the significant fact that in the Aryan languages there is no primitive term for autumn, and that it was the last of the four seasons to receive a name, is by itself a tolerably clear indication that the undivided Aryans had not reached the agricultural stage of civilization. Among the Aryans, as well as among the Ural-Altaic races, the oldest of the names of the seasons are the winter (*hiems*), the time of snow, when the cattle had to be stabled, and summer, when the herds went out to pasture.

Even in the historical period there were Aryan tribes who had not reached the agricultural stage. Tacitus describes the Sarmatians as nomads "in plaustro equoque viventibus;" ‡ and Cæsar tells us that corn was not grown in the interior of Britain, but only in the South,

* Schrader, *Urgeschichte*, pp. 340–353. † Keller, *Lake Dwellings*, p. 283.
‡ Tacitus, *Germania*, 46.

which was inhabited by Belgic tribes which had recently immigrated from Gaul. No cereals have as yet been found in any of the British round barrows; but the querns and mealing stones, which are not infrequent, are supposed to indicate that grain was not unknown. This, however, is not decisive, as they may have been used for pounding acorns or wild oats.

Cuno ingeniously argues that the undivided Aryans must have been acquainted with cereals, because the name of the mouse, which means "the thief," is found in Greek, Latin, Teutonic, Slavonic, and Sanskrit. What, he asks, could the mouse have stolen except corn? But this argument is not conclusive, as in some of the South German lake dwellings we find no corn, but stores of hazel nuts, which might have been pilfered by the mouse.

Our English word *grist*, which is related to the German *gerste*, the Latin *hordeum*, the Greek *κριθή*, and the Armenian *gari*, is, however, an indication that some kind of grain, probably barley, was known. But the cereal, whatever it was, may have grown wild; or, as the herdsmen moved to their spring pastures, a forest-clearing may have been made with the aid of fire, and grain may have been sown and gathered in the autumn; but there can have been no regular tillage, no permanent enclosures, and no property in land.

Barley, which was probably the earliest cereal cultivated by the Aryans, was succeeded by wheat and spelt. The name of flax, *linum*, is very widely spread, and may be traced in all the Aryan languages of Europe—Latin, Greek, Celtic, Gothic, and Slavonic. Hemp, as well as oats, rye, pease, beans, and onions do not, however, belong to the primitive Aryan epoch.

In words connected with tillage there is a great gulf between the Aryan languages of Asia and those of Europe. The Indo-Iranian languages have special terms for plowing, sowing, and reaping, which do not extend to Europe; and we may probably conclude that the Asiatic Aryans had not advanced beyond the pastoral stage at the time of the separation.

The curious agreement between Greek and Sanskrit in words denoting weapons has been already remarked. Not less curious is the correspondence between the Latin, Greek, Teutonic, and Slavonic words which refer to agriculture, and the disagreement in these languages of terms which denote weapons. This seems to indicate that the Italic and Hellenic races must, at the time when agriculture began, have been dwelling in peaceable proximity in some more northern region, probably in Danubian lands, in contact with Slaves and Teutons, deadlier weapons of offense being required when they moved southwards to win new homes in the Mediterranean lands.

The primitive plow was doubtless a crooked branch of a tree, tipped probably with the tine of a stag's antler. The Finnic word *kar-a* designates both a plow and the branch of a tree, and the Indian name of the plow, *spandana*, also means a tree. That the Aryan plow was unprovided with a plowshare may perhaps be gathered from the etymology of the word *sock*, which is used in provincial English to denote a plowshare. This is the French *soc*, and the old Irish *socc*, a plow, and can only be explained from the old Irish *soc* (old Welsh *husc*), a sow. In like manner the Greek name for the plowshare, ὕννις, ὕννη, must be connected with ὗς, a sow. The stages of meaning must have been first the sow, then the sow's snout, then the plowshare, and lastly the plow. Now, as the pig did not belong to the earlier stages of Aryan culture, we may perhaps conclude that the primitive plow was unprovided with a snout.

The foregoing conclusions as to early Aryan agriculture are fairly in accord with the archæological evidence. In the pile dwellings at Laibach in Carniola both flax and grain are absent, but hazel nuts in enormous quantities were found, together with the kernels of the water chestnut, *Trapa natans*, which, according to Pliny, was made into bread by the Thracians.* At Schussenried, in Würtemberg, in addition to hazel nuts and acorns, wheat is abundant, but neither woven flax nor spindle whorls have been discovered, the only fabric being a bit of rope made from the bark of the lime tree. At Mooseedorf, which is probably the oldest of the Swiss lake dwellings, barley and flax, as well as wheat, have been discovered. The pea is found towards the close of the stone age, while beans and lentils first appear in the bronze age; and oats have not been discovered in any settlement older than Möringen, which belongs to the end of the bronze age. Hemp has not been found at all. In the pile dwellings of the bronze age in the valley of the Po, when the pig and the horse had been domesticated, we find wheat, beans, and flax, with the addition of the vine, which has not been discovered in any of the Swiss settlements.†

6.—*Food.*

We have seen that in some of the oldest lake dwellings, notably those of Germany, the only farinaceous food consisted of hazel nuts, acorns, and the water chestnut. By the time the Aryans had reached Switzerland they had learned to cultivate barley and wheat; and in Cæsar's time corn was grown in the south of Britain, though not, as he tells us, in the center of the island. Acorns were roasted in earthen pipkins, corn was pounded between two stones, and cakes of kneaded meal were baked in the hot ashes. Meat was roasted on spits, or baked in the ashes, but the art of boiling seems to have been unknown. The Latin *jus* (Sanskrit *yus*) is believed to have denoted the gravy and dripping from the roasted meat, rather than broth. The

* Keller, *Lake Dwellings*, p. 617. † Schrader, *Urgeschichte*, pp. 354-364.

Germans, according to Pomponius Mela, feasted on raw flesh, but this was forbidden by the Viking laws. Horseflesh was largely eaten in the neolithic age, and even in the historic period by the Iranians and Scandinavians.

It seems difficult to believe that the art of making cheese was unknown to the Northern nations till they had come in contact with Latin civilization, but such appears to have been the case, since the name is a loan-word from the Latin *caseus*, and spread from the Teutonic to the Slavonic languages. Koumis, however, seems to have been made both by the Goths and the Lithuanians, whose nobles intoxicated themselves on a fermented beverage prepared from the milk of mares.*

It is very remarkable that there is no common name for fish in the Aryan tongues. The Zend and Sanskrit words agree; so do those in Latin, Celtic, and Teutonic, as well as those in Lithuanian and Armenian, while the Greek name is isolated.† This defect in the linguistic record is not by itself decisive, since the primitive word for "father" has disappeared from Slavonic, for "sister" from Greek, and those for "son" and "daughter" from Latin. But in the case of fish an inference may be safely drawn, as the divergence of the names is curiously corroborated by other evidence, so that we may conclude that it was only after the linguistic separation that fish became a usual article of food among the Aryans. Not only is the name for fish different in Greek and Latin, but all the terms connected with the art of fishing—the net, the line, the hook, and the bait—were independently evolved.

It is noteworthy that while the Greek word for fish cannot be traced in Latin, the Latin name, *piscis*, reappears both in Celtic and Teutonic, one out of many indications that the final separation between Greeks and Latins was earlier than that between Latins and Celts, or between Celts and Teutons.

There is no mention in the Vedas of fish being eaten, and only exceptionally in Homer, while "fish-eater" is used as a term of reproach by Herodotus. In the pile dwellings of the valley of the Po, which were so favorably situated for the practice of the fisherman's art, neither hooks nor any other implements for catching fish have yet been found. Fish-hooks are extremely rare in collections of prehistoric antiquities, the great museum at Dublin containing only one single specimen.‡ In the very early lake settlement at Schussenried, in Würtemberg, where the flint implements are of a type as primitive as those in the kitchen middens, hardly any fish bones have been found.

The taste for fish and the art of fishing seem to have been developed at a comparatively late period. Fish hooks have been found

* Hehn, *Wanderings of Plants and Animals*, p. 55.

† Schrader, *Urgeschichte*, p. 171.

‡ Lubbock, *Prehistoric Times*, p. 33.

in the Celtic settlement of Hallstadt, in Austria, which is of the iron age, and others of the same pattern at Nidau, on the Lake of Bienne, and elsewhere, but they are more common in settlements which come down to the iron age than in those which belong to the ages of bronze or stone.

In the kitchen middens of Denmark, fish, especially herrings, formed an important article of food. This fact, taken in connection with the absence of any common Aryan word for fish, and the curious aversion to fish among the Indian, Hellenic, Italic, and Celtic races, is not without its bearing on the ethnic affinities of the primitive Aryans.

Oysters formed no inconsiderable portion of the food of the people of the Danish kitchen middens, and oysters were placed in the tombs of the royal personages buried at Mycenæ. The name is found in all the Aryan languages of Europe,* but is wanting in the Indo-Iranian family. If the Aryans originated in Europe, the loss of the word in lands where the oyster is unknown is perfectly intelligible; but if the European nations successively migrated from Central Asia, the adoption of the same designation is difficult to explain, more especially since the linguistic gulf between Greeks and Celts, or between Teutons and Latins, is more profound than that between Iranians and Slaves, or Greeks and Indians.

The vine appears to have been unknown to the lacustrine people of Switzerland. A vine stock was found in one of the pile dwellings in Italy, but the art of making wine was probably introduced by Greek colonists.† The name is probably a loan-word obtained from the Semites.

The earliest intoxicating drink was prepared from wild honey. Words etymologically related to our English *mead* reappear in Sanskrit, Greek, Celtic, Slavonic, and Latin, denoting either honey, sweetness, mead, wine, or drunkenness. In Northern Europe mead was replaced by beer, the English word *ale* corresponding to the old Prussian word *alu*, which means mead.

7.—*Dress.*

The clothing of the Aryans of the neolithic and even of the bronze age consisted chiefly of the skins of beasts, the flesh, and perhaps the hair, having been removed by stone scrapers, which are extremely numerous, even as late as the bronze age. These skins were sewn together by means of bone needles, which are found in great abundance. Cæsar says of the Britons, *pellibus sunt vestiti*, and Tacitus tells us that the same was the case with some of the Germans. In the Swiss and Italian pile dwellings fragments of leather, tanned by some rude but effective process, have been found.

Flax, whose very name implies that it was used for weaving (Latin

* Latin, *ostrea*; O. H. G., *auster*; Old Irish, *oisridh*; Russian, *ustersu*; Greek, ὄστρεον.

† Hehn, *Wanderings of Plants and Animals*, pp. 72-74.

plecto, German *flechten*), was spun and woven by the women of the neolithic household, as is evidenced by the spindle whorls and loom weights so abundantly found in the Swiss dwellings of the stone age. In several settlements linen fabrics have been discovered. The threads of the warp, consisting of two fibers of flax twisted together, must have been hung with weights from a horizontal bar, the similar threads of the woof being interlaced by means of needles of bone or wood. That the flax was cultivated is shown by the stores of linseed which have been found. In some of the earlier settlements in Southern Germany, where flax was unknown, ropes and mats were made of bast, prepared from the bark of the clematis or the lime. There is no evidence that hemp was known in the age of stone or even of bronze.

Curiously enough, though flax was so commonly used for weaving in the stone age, there is no evidence in the pile dwellings of Switzerland or Italy of the weaving of wool, even in the bronze age, when sheep had become numerous. Evidently the sheep-skins were worn with the wool on, as is still the case with the peasants of Central and Southern Italy. Woolen fabrics have, however, been found in Jutland, and in Yorkshire, associated with interments of the bronze age.* From the Rig Veda it would appear that wool rather than flax was the material employed by the weaver. Bone needles are found in early deposits of the neolithic age, as at Laibach, where flax and even cereals are absent; and our verb "to sew" can be traced in the Sanskrit, Greek, Latin, Teutonic, and Slavonic languages. The word probably denoted the stitching together of skins, since in the Swiss pile dwellings, where linen fabrics are abundant, only one hem and a pocket laced on with string have been discovered, and there is no trace either of a seam or of a cut piece.† Probably the texture of the linen was too flimsy to admit of cutting or sewing. The woven fabric seems to have been worn only as a wrapper, since there is no sign of any garments having been fitted to the figure. The first trace of any such advance in the art of tailoring is afforded by the word "breeks," which, as is proved by the old Irish *bracæ*, must, at the period when the Celts still inhabited Central Europe, have been borrowed from the Celts by the Teutons and the Slaves. But these "breeks" were doubtless made of skins.

No distinction seems to have been made in early times between the dress of the women and the men, which is itself a sign of a very primitive stage of civilization. In Greece the *chiton* and the *himation* were worn both by men and women; at Rome the toga was originally the dress of both sexes; and Tacitus says of the Germans, *nec alius feminis quam viris habitus*.

* Greenwell, *British Barrows*, pp. 32, 376; Lubbock, *Prehistoric Times*, p. 48.

† Keller, *Lake Dwellings*, pp. 56, 512.

The Agathyrsi, in Transylvania, painted or tattooed their bodies, and ruddle has been found in so many deposits of the stone age that we must assume that the practice was common, if not universal.

The antiquity of the practice of shaving has been the subject of much controversy, and affords a good instance of the way in which philological conclusions have been corrected by archæology.

Benfey argued that the primitive Aryans shaved their beards, on the ground of the identity of the Greek *ξυρόν* and the Sanskrit *kshurá* —words which both denote a razor; and he explains the absence of the word from the rest of the Aryan languages by the hypothesis that, in the course of their wanderings, the other Aryans may have lost elements of the primitive culture. But since it would be difficult to shave with a stone, however sharp, and as the Swiss pile buildings show that the early Aryans were still in the stone age, and since no razors were found in the very early cemetery at Alba Longa, Helbig argues that this word may have originally denoted the flint flakes which were used for scraping the hair off hides, found in great numbers in the earliest settlements, the name being afterwards transferred, after the invention of metals, to razors for shaving the chin.*

8.—*Habitations.*

The undivided Aryans were no longer troglodytes, but had learned to construct huts. It has been already noticed† that the long barrows of the pre-Aryan population of Britain are imitations or survivals of the cave, while the round barrows of the Aryan invaders were constructed on the model of the circular hut.

These huts were of two kinds—the summer hut, constructed wholly above ground, and the winter hut, which was a circular roofed pit. As to the former, we have to rely chiefly on descriptions or pictorial representations; of the latter, we have actual remains.

The pit dwellings at Fisherton, near Salisbury, and elsewhere, the remains of which are still to be seen, are proved to be of neolithic age by the absence of metal, and by the spindle whorls of baked clay and fragments of rude pottery. The pits are carried down through the chalk to a depth of from seven to ten feet, and the roofs were made of interlaced boughs coated with clay. They were entered by tunnels excavated through the chalk, sloping downwards to the floor. We learn also from Tacitus that in the winter some of the German tribes lived in similar holes dug in the earth, the roofs being plastered with the dung of cattle.‡

That the undivided Aryans also constructed huts above ground, with roofs, doors, and door-posts, is proved by the linguistic evidence.

The Latin word *domus* reappears in Sanskrit, Greek, Celtic, and

* Schrader, *Urgeschichte*, p. 53. † See p. 45, *supra*. ‡ Tacitus, *Germania*, cap. 16.

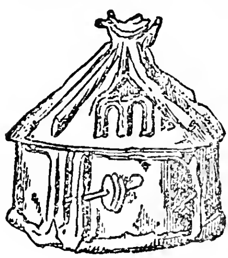
Slavonic, while the German *dach*, roof, which has become *thatch* in English, may be traced in Greek, Latin, Celtic, and Lithuanian. Our English word *door* is the same word with the Sanskrit *dvara*, the Greek *θύρα*, the old Irish *dorus*, and the Latin *fores*, while the name for the door-posts, in Latin *antæ*, appears also in Zend and Sanskrit.

For the real character of these houses, whose existence throughout the whole Aryan region is established by the foregoing linguistic facts, we have to rely on the archæological evidence, which proves beyond contention that they were not houses, in the modern sense of the word, but mere huts of the rudest kind.

Even in the bronze age, as late as the eleventh century B.C., the Umbrians, who among the Aryan peoples were second only to the Hellenes in the civilization they had attained, possessed no better habitations than wattled huts, from nine to twelve feet in diameter, daubed with clay, and thatched with reeds. No trace of masonry or mortar has been discovered in their settlements.*

According to the testimony of Strabo, which is borne out by the evidence of the carvings on the column of Marcus Aurelius at Rome, the Celtic or Teutonic tribes on the Danube, even as late as the second century A.D., lived in reed-thatched huts of wood or wicker-work. They were undoubtedly ignorant of the use of mortar, as also were the Germans in the time of Tacitus.

Even imperial Rome must at one time have contained nothing better than such huts, as is proved by two venerable survivals. The *Casa Romuli* on the Palatine was a hut of twigs and reeds; and the house of Vesta in the Forum, the oldest seat of Roman worship, long preserved under the guardianship of the sacred virgins, was a mere hut of wicker-work and straw.†



HUT URN FROM ALBA LONGA.

The hut urns discovered at Alba Longa doubtless represent the early abodes of the Aryan settlers in Italy.

The inhabitants of the Swiss lake dwellings had learned to fell large trees with their stone axes, and drive the piles deep into the soft mud, and to construct on the piles platforms of beams which were mortised together with considerable skill. On these platforms they built square or circular huts, with perpendicular walls of poles and wattle, plastered with clay, thatched with bark, straw, or reeds, and furnished with a wooden door, a clay floor, and a sandstone slab for a hearth. The modern Swiss *châlet* seems to be a survival of these pile dwellings, the living rooms being on the first floor, the lower story merely serving as a storehouse for fuel or fodder.

Even when the Rig Veda and the Avesta were composed the craft

* Helbig, *Die Italiker in der Poebene*, p. 47. † *Ibid.*, p. 51.

of the mason was unknown, the habitations of the Indo-Iranians long after their separation being merely huts of wood or bamboo thatched with reeds or straw. The Iranians also constructed pit-dwellings roofed over with poles and thatch like those of the neolithic people of Britain.

Since the Gothic *gards*, which corresponds to the Latin *hortus* is represented in Greek by *χόρτος*, which denotes primarily place for dancing, we cannot conclude from these words that the huts or seed-plots of the primitive Aryans were fenced and surrounded by inclosures.

The mason's art, and the use of mortar, are believed to have been introduced into Europe by the Phœnicians. The megalithic tombs at Mycenæ, and the huge dolmens of France and Britain, are at once a testimony to the skill of the neolithic Aryans, and a proof that the use of mortar was unknown. The vast labor of roofing these structures with enormous slabs weighing many tons would never have been undertaken if the builders had known how to construct them of smaller stones cemented together by mortar. The huge megalithic circle at Stonehenge, with its five great trilithons, one of the most impressive structures in the world, is now generally assigned by archæologists to the brachycephalic race which first introduced bronze weapons and Aryan speech into Britain, and forms an astounding testimony to the bodily and mental powers of those who planned and executed it.

9.—*The Boat.*

Some sort of boat, or rather canoe, must have been constructed in the primitive period, since the Latin *navis* can be traced in Sanskrit, Greek, Celtic, and Teutonic. But the word cannot at first have denoted more than the trunk of a tree hollowed out by the stone axe, with the aid of fire. This is indicated by the etymological relation of the Sanskrit *daru*, a boat, to the English *tree*, and the Celtic *daur*, an oak. Similarly the old Norse *askr* denotes a boat as well as an ash tree. Several "dug-outs," hollowed out of a single trunk, have been found in the neolithic lake settlements of Switzerland, Italy, and Ireland. The Celtic *barka*, the old Norse *barki*, and the English *barge* and *barque* are indications that the Northern Aryans also constructed canoes of the bark of some tree, probably the birch.*

The canoes were propelled by oars or poles, since the Latin *remus* can be traced in Sanskrit, Greek, Celtic, and Teutonic. Sails, however, were unknown in the primitive period, as is shown by the fact that the German *segel*, our *sal*, is a loan-word from the Latin *sagulum*. Thus the Teutonic invasions of England were only made possible by previous contact with Roman civilization.

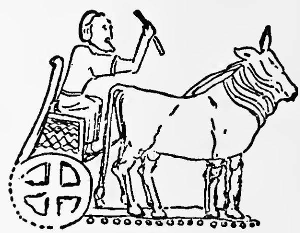
* Kluge, *Etymologisches Wörterbuch*, pp. 18, 35.

An examination of the nautical terms in Latin yields some curious results. According to Georg Curtius, they divide themselves into three classes. We have first the proto-Aryan word *navis* and *remus;* secondly, *velum* and *malus*, which are words of Italic origin, not belonging to the general Aryan vocabulary; and thirdly, a large number of loan-words from the Greek, such as *gubernare*, *ancora*, *prora*, *aplustre*, *anquina*, *antenna*, *faselus*, *contus*, and *nausea*. Hence it would appear that the undivided Aryans had invented canoes and oars, that the mast and the sail were used on inland waters after the linguistic separation of the Italic and Hellenic races, while the fact that the Latin word for sea-sickness is a loan-word from the Greek may indicate that the Italic peoples did venture to navigate the sea before they came in contact with Greek civilization.* It has already been noted that while the words relating to pastoral and agricultural pursuits are to a great extent identical in Greek and Latin, those referring to fishing, such as the names of the net, the line, and the hook, are entirely unrelated.†

10.—*The Ox-Wagon.*

Indubitably the greatest invention of the primitive Aryans was the ox-wagon. The names of the wheel (Latin, *rota*), of the yoke (Latin, *jugum*), of the wain (Sanskrit, *vahana*), and of the axle (Sanskrit, *aksha*), are common to all Aryan languages. The old Irish *carr* and the Latin *carrus* may also be compared with the *karama*, which, Hesychius tells us, was the name of the covered wagon, or tent upon wheels, in which the nomad Scythians moved from place to place in search of pasturage for their cattle.

On a Thracian coin of the beginning of the fifth century B.C., which is attributed to the Odomanti, who inhabited the pile dwellings in Lake Prasias, we have the earliest representation of the primitive Aryan ox-cart.‡ The body is of wicker-work, poised over the axle, and is drawn by means of a pole by a yoke of oxen.



A similar ox-cart, conveying three female captives, is depicted on a bas-relief of Shalmaneser.§ At the beginning of the New Empire both the Egyptians and the Hittites possessed war chariots drawn by horses. The signet-ring of Darius Hystaspes represents a lion hunt, in which the king is mounted on a car of the same construction as that seen on the coin of the Odomanti, but drawn by horses instead

* Schrader, *Urgeschichte*, p. 112. † Helbig, *Die Italiker in der Poebene*, p. 75.

‡ Head, *Historia Numorum*, p. 180.

§ Lenormant, *Histoire de l'Orient*, vol. iv., p. 197.

of oxen;* and the Persian kings are frequently thus represented on their coins.

The primitive ox-wagon must have been constructed without metal. The wheel and the axle were probably in one piece, made out of the section of the trunk of a tree, thinned down in the middle so as to form an axle, and leaving the two ends to serve as wheels. Such wagons are still used in Portugal. They are drawn by oxen, and have two wheels only. A log is cut from the trunk of a tree, and the centre is hacked away, leaving two solid wheels united by an axle.† A disc of walnut wood, apparently used as a wheel, was found in an Umbrian lake dwelling at Mercurago, near Arona, in Northern Italy.‡

11.—*Trades.*

In the primitive age there could have been little division of labor. The earliest trace of a trade is that of the makers of flint implements, an art which requires considerable skill. At Brandon, in Suffolk, the neolithic people obtained flints by excavating shafts and galleries in the chalk with picks made of stags' antlers; and at Cissbury, in Sussex, where thousands of flint implements have been found, there must have been a regular factory of neolithic implements.§ As the undivided Aryans were in the stone age there is no common name for the smith, whose occupation must have been specialized early in the bronze age. Down to a late period, however, bronze implements were imported into Britain from the Continent. In the Vedas only two trades are mentioned, those of the smith and the carpenter. In Homer the τέκτων is both mason, carpenter, and shipwright.

The art of pottery dates from the beginning of the neolithic period, but there is no well-recorded case of pottery being found in association with palæolithic implements.‖ The neolithic pottery was made by hand, and there is no certain trace of the invention of the potter's wheel before the later settlements of the bronze age, such as those at Concise, where wheel-made vessels have been found.¶ With the invention of the wheel the potter's art seems to have become a trade, as is evidenced by the more elaborate and conventional style of ornament which is gradually introduced.

The invention of the potter's wheel may be approximately dated by the facts that it was known when the Homeric poems were composed, while all the pottery found in the burnt city at Hissarlik is hand-made,** and that no wheel-made pottery has been found in any of the North Italian settlements of the bronze age. In some of the amphoræ

* Head, *Coinage of Lydia and Persia*, p. 31.

† Pösche, *Die Arier*, p. 98.

‡ Keller, *Lake Dwellings*, p 350.

§ Dawkins, *Early Man in Britain*. p. 276

‖ *Ibid.*, pp. 209, 227, 229; Mortillet, *Le Préhistorique*, p. 558.

¶ Keller, *Lake Dwellings*, p. 278.

** Schliemann, *Ilios*, p. 32.

found at Hissarlik the forms seem to have been imitated from those of water skins, the handles being survivals of the fore-legs of the animal, while the navel has developed into a central ornament, which was supposed by Dr. Schliemann to represent the head of an owl.

12.—*Social Life.*

It has often been assumed that the Greeks brought with them into Hellas a somewhat high degree of culture, but Thucydides possessed probably a keener historical insight when he acknowledges that they were at first barbarians. The primitive civilization of the Italians and Hellenes cannot have been higher than that of the undivided Aryans, or so high as that of the Sarmatians, Scythians, Dacians, Celts, and Teutons, as described by ancient writers. The culture of Italy and Hellas must have been the result of a lengthened process of historical evolution, stimulated, and to a great extent imparted, by contact with the higher culture of the Semites, which again was derived from the proto-Babylonian people.

It is evident that even as late as the time when the Homeric poems were composed the Greek princes lived in dirt and squalor. There were muck-heaps in the palace of Priam, and at the door of the palace of Ulysses. In the hall where the suitors caroused, the hides and feet of oxen and the offal of beasts recently slaughtered for the feast lay upon the floor.*

When we read that at the funeral of Patrocles Achilles slaughtered, with his own hand, twelve noble Trojan captives, four horses, and two dogs, and when we read the description of his dragging by the heels the body of Hector thrice around the walls of Troy, it is manifest that the golden age imagined by the poets was in reality an age of brutal savagery. In the older Greek myths and legends we find traces of human sacrifice, such as prevails at Dahomé, of infanticide, of the exposure of children, of the capture and sale of wives, which must be regarded as survivals from an earlier stage of barbarism.

We find traces of the same practices among other Aryan nations. Human sacrifice prevailed among the Celts in Cæsar's time, and among all the Teutonic tribes,† and did not cease in Iceland before the conversion of the Scandinavians to Christianity at the close of the tenth century.

When a war-galley was launched by the Vikings, men were bound to the rollers, so that the keel was sprinkled with their blood.‡ The practice of breaking a bottle of wine over a ship's stem at the launch may be regarded as a survival of this savage Scandinavian practice of

* Homer, *Il.*, xxiv. 640 ; *Od.*, xvii. 290 ; xx. 299 ; xxii. 363.

† Maclear, *History of Christian Missions*, p. 28.

‡ Vigfusson and Powell, *Corpus Poeticum Boreale*, vol. i., p. 410.

"reddening the rollers," as it was called, just as the custom of leading an officer's charger before the coffin at his funeral is a survival of the old practice of sacrificing a chieftain's wives and horses at his pyre.

There is reason to believe that infanticide, human sacrifice, and even cannibalism were practiced in Britain, if not by the Celts, certainly by the Iberians; and Mr. Bateman affirms, as the results of his explorations among prehistoric graves, that there is accumulated evidence to prove that wives were burnt on the funeral pyres of their deceased husbands.* There can be no doubt that it was an early Aryan custom to kill the widow at her husband's funeral. Children were exposed, and infant daughters especially were put to death at the father's will. Among the Indians, the Iranians, the Scandinavians, and the Massagetæ, the aged were killed when they became an encumbrance.

Even the people of the Swiss lake dwellings fashioned the skulls of their enemies into drinking cups,† and the Greek κόμβος, which may be traced in Sanskrit and Zend, may indicate that the same savage custom was not unknown to the Indo-Iranians and the Greeks. The Sanskrit word *gola*, a round pot, reappears in Greek, and the Latin *testa* in Zend and Lithuanian.

The primitive Aryans were undoubtedly polygamists. Herodotus attributes polygamy to the Persians, and Tacitus to the Germans; and there are traces of ancient polygamy in the Vedas. But primogeniture seems to have been the Aryan custom from the first. Even at the very earliest period the Aryans had passed beyond the polyandrous stage of society.

The tribal community of women, of which obscure survivals may be traced in the customs of exogamy, and of inheritance through the mother, doubtless existed among non-Aryan tribes, such as the proto-Medes, the Lycians, the Etruscans, and the Picts, and in more recent times among the Lapps, the Ostiaks, the Tunguses, and the Todas.

The curious custom of the *couvade* seems to be Iberian rather than Aryan. It is practiced in Corsica, the South of France, the North of Spain, and in Western Africa, regions where we find traces of the Iberian race.‡

Marriage by purchase, which prevailed among the Germans, the Thracians, the Latins, and the Vedic Indians, is a stage in advance beyond marriage by capture, of which we find traces among the ruder Dorians, and perhaps in Italy.

Only three words denoting family relationships are found in every branch of Aryan speech. These are the names for mother (*matar*),

* Lubbock, *Prehistoric Times*, p. 176.

† Gross, *Les Protohelvètes*, p. 107.

‡ Lubbock, *Origin of Civilization*, p. 18; Guest, *Origines Celticæ*, vol. i., p. 63; Tylor, *Early History of Mankind*, p. 303.

brother (*bhratar*), and father-in-law (*socer*). The last* is of especial value, as it affords a conclusive indication of the institution of marriage, and of orderly family arrangements among the undivided Aryans.

The primitive designation of the daughter-in-law† is nearly as widely spread, being wanting only among the Iranians, the Celts, and the Lithuanians. Such terms are unknown among savages, and go further than any other words that have been adduced to establish the social relations of the Aryans at the very earliest epoch.

The names for father (*pitar*), husband (*pati*), son (*sunus*), daughter (*duhitar*), as well as for sister, step-mother, and son-in-law, are also believed to be primitive, though they are wanting in one or more of the Aryan languages. But we must beware of such little idyllic pictures as that of "the father calling his daughter his little milkmaid,"‡ as it is more probable that *duhitar* means simply the "suckling," like the Latin *filia*, and not the milker of the cows.§

The unit of society was the family, comprising wives, children, and slaves; but investigations into the common Aryan names for "nation" or "tribe" yield no very definite result. Probably it was at some period later than the linguistic separation that the family grew into the gens, thorp, vicus, or *φρατρία*. Neighboring *gentes* then combined for mutual protection, and some central hill, where the dead were buried, was surrounded by an earthen mound as a place of refuge in time of common peril, and the tribe was governed by the *rex*, whose chief duty was to declare the ancient customs of the tribe. The oldest words for "law" primarily denote "custom." The duty of blood revenge and the permission to atone for blood by a *wergeld* seem to have been among the earliest sanctions of customary law, and may be traced among communities so widely separated as the Afghans, the Homeric Greeks the Iranians of the Avesta, and the Germans of the time of Tacitus.

That the primitive Aryans had nothing which we can call science may perhaps be inferred from the fact that the Teutonic word "leech," for a professor of the healing art, though found in Celtic and Slavonic, does not extend to the Southern or Eastern tongues. The Aryan words for herbs, healing drugs, poison, and magic are mostly unrelated. The Aryan languages, however, possess common words denoting wound, vomit, cough, and heal.‖

That the undivided Aryans had devised the decimal system of notation, enabling them to count up to a hundred, is a proof that they

* Latin, *socer;* Slavonic, *svekru;* German, *schweiger;* Welsh, *chwegron;* Greek. *ἑκυρός*; Sanskrit, *çvaçura*.

† Latin, *nurus;* Greek, *νυός*; Sanskrit, *snushâ;* Slavonic, *snucha;* Teutonic, *snura*,

‡ Max Müller, *Essays*, vol. i., p 324.

§ Rendel, *The Cradle of the Aryans*, p. 11.

‖ Schrader, *Urgeschichte*, p. 409.

were in advance of some existing tribes of savages, who are only able to count up to three or five. The notation was digital, as is shown by the fact that the word *five* means hand or fist. They were, however, unable to count up to a thousand, a number which is differently designated in Latin, Greek, Sanskrit, and German.

The oldest Aryan designation for periods of time was the "month," which takes its name from the moon, the universal "measurer" of time. The week is not a primitive conception, the months being divided into half-months by the light half and dark half of the moon. The names of the week and autumn were the last to be devised. The name of the "year" is not primitive. The Aryans noticed the winter, *hiems*, the time of snow, and the summer, and reckoned at first by seasons rather than by years. The Greek ἔτος is etymologically identical with the Latin *vetus*, and meant the "old" or past time. The Latin *annus* is the ring or circle of the seasons, while the Teutonic "year" is the Greek ὥρα, and meant the "season" or the "spring." It has been already noted* that the fact of the autumn being the last of the seasons to receive a special name is an indication that the primitive Aryans were in the pastoral rather than the agricultural stage of civilization.

The primitive Aryan worships and conceptions of religion are so important in any estimate of the culture they had attained that their discussion must be reserved for a separate chapter.

The most widespread Aryan word for sea is *mare*, but since this only means "dead" water as distinguished from running water, it does not follow that the primitive Aryans knew the sea. The word may have originally designated merely a stagnant lake or pond. Perhaps the most singular defect in the linguistic record is the want of any common word for river.

We may now briefly sum up our conclusions, which are essentially those of Hehn and Schrader, and have been obtained by correcting the earlier conclusions of philology by the safer evidences of archæology. We find the undivided Aryans were a pastoral people, who wandered with their herds as the Hebrew patriarchs wandered in Canaan, or as the Israelites wandered in the desert. Dogs, cattle, and sheep had been domesticated, but not the pig, the horse, the goat, or the ass, and domestic poultry were unknown. The fibers of certain plants were plaited into mats, but wool was not woven, and the skins of beasts were scraped with stone knives, and sewed together into garments with sinews by the aid of needles of bone, wood, or stone.

The food consisted of flesh and milk, which was not yet made into cheese or butter. Mead, prepared from the honey of wild bees, was the only intoxicating drink, both beer and wine being unknown. Salt was unknown to the Asiatic branch of the Aryans, but its use had

* See p. 95, *supra*.

spread rapidly among the European branches of the race. In winter they lived in pits dug in the earth, and roofed over with poles covered with turf or plastered over with cow dung. In the summer they lived in rude wagons or in huts made of the branches of trees. Of metals native copper may have been beaten into ornaments, but tools and weapons were mainly of stone. Bows were made of the wood of the yew; spears of ash; and shields of woven osier twigs. No metal was used in the construction of their wagons; and trees were hollowed out for canoes by stone axes aided by the use of fire.

According to Hehn, the old or sick were killed, wives were obtained by purchase or capture, infants were exposed or killed, and after a time, with tillage, came the possession of property, and established custom grew slowly into law. Their religious ideas were based on magic and superstitious terrors, the powers of nature had as yet assumed no anthropomorphic forms, the great name of Dyaus, which afterwards came to mean God, signified only the bright sky. They counted on their fingers, and the earliest abstract conception was decimal numeration, but they had not attained to the idea of any number higher than a hundred.

13.—*Relative Progress.*

We have hitherto considered mainly the civilization attained by the Aryans before the linguistic separation, but the science of linguistic palæontology yields some interesting results as to the relative progress of the different Aryan families.* We have already seen that the advance was unequal, some nations, for instance, being still in the stone age, while others were acquainted with bronze, and others with iron. Culture spread by means of commercial intercourse along the great trade routes, from Phœnicia to Greece and then to Italy, from Italy to the Celts, and from Celts to Germans.

It is plain, from the character of the culture words common to Zend and Sanskrit, that the Indians and Iranians had before their separation advanced farther in the path of civilization than any of the other Aryan nations. They knew themselves as a united people (Sanskrit *drya*, Zend *airya*). They had common words for bridge, column, battle, fight, sword, spear, and bowstring, and they could count up to a thousand. But the agreement in religious terms is the most striking proof of the stage of culture they had reached. They had common words for priest, sacrifice, song of praise, religious aspergation, for the sacred soma drink, for God, Lord, for heroes and demons, and for Mithra, the god of light. The chief Indian god, Indra, the god of storms, who in the Rig Veda is a beneficent deity, becomes in the Avesta a malignant power. It was formerly believed that a religious

* See Schrader, *Urgeschichte*, pp. 74-96.

schism was the primary cause of the separation of the Indians and Iranians, but this notion is now universally given up.

Next to the Indians and Iranians the Slaves and Teutons exhibit the greatest community of culture. They have common words for gold, silver, and salt; for hoe, quern, beer, ale, and boots; for swan, herring, and salmon; for rye and wheat; and for many trees, including the aspen, the maple, the apple, and the wild cherry. They have the same name for the smith, and for many weapons; for autumn and thousand; for various maladies; as well as for lies, shame, sorrow, trouble, scorn, and, perhaps more significant than all, we discover that venal vice was accounted opprobrious.

But there are a host of culture words common to all Teutonic languages, which they do not share with their near neighbors, the Slaves.

In the first rank of such words are those which indicate that while the Slaves were an inland people the Teutons lived near the sea. Such are designations for sea, haven, cliff, strand, island, flood, whale, seal, gull, and many words connected with the building and steering of boats. Among trees the name of the lime; among animals those of the roe, the reindeer, the squirrel, and the fox are peculiar to the Teutons. Many names of weapons, and terms connected with metallurgy, cookery, and dress, are confined to the Teutons. Hose and shoes are peculiar to the Teutons, breeks are common to Celts and Teutons, and boots to Teutons and Slaves.

The Teutons have a special name for the horse, and peculiar terms connected with horsemanship, such as reins, spurs, and saddle. They have a new name for the house, which, however, was still built of wood, and new terms denoting autumn and winter, as well as for battle, victory, fame, honor, as well as for letters and the art of writing; while the names of deities and the words referring to religion are almost wholly different among the Teutons and the Slaves.

On the other hand, the undivided Slaves, after their separation from the Teutons, acquired special terms to denote iron, knife, javelin, sword, spur, needle, anchor, plow, plowshare, corn, wheat, barley, and oats; but there are no words common to all the Slavonic dialects for steel, paper, velvet, or pavement. The still undivided Slaves cultivated the cabbage, pea, bean, lentil, leek, poppy, and hemp; they knew the oak, lime, beech, birch, willow, fir, apple, plum, and nut; they had common words for weaving and for clothes, for woodwork and ironwork; they dwelt in villages, and had huts or houses made of intertwined boughs; but all their terms connected with masonry are loan-words from foreign tongues. They had common words to designate law and rights, family and tribe, but none for inheritance or property—an indication that the land and all connected with it still belonged to the undivided house-family, or *mir*.*

* Schrader, *Urgeschichte*, pp. 90-93.

The relation between the Celts and Germans is peculiar. Linguistically they are far apart, proving that the separation dates from a very early period; but there are numerous culture words of an advanced character which seem to show that at some period subsequent to the original separation they were in geographical contact, the Celts, as the more civilized race, exercising a political supremacy over some of the Teutonic tribes. The line of contact, as has already been suggested, was probably the range of mountainous forest which separates the basins of the Elbe and the Oder from the basin of the Danube.

The connection of the Celtic and Italic languages is structural. It is much deeper than that of Celts and Teutons, and goes back to an earlier epoch. Celts and Latins must have dwelt together as an undivided people in the valley of the Danube, and it must have been at a much later time—after the Umbrians and Latins had crossed the Alps—that the contact of Celts and Teutons came about.

We have already seen that the Teutons got their knowledge of iron from the Celts, and it will be shown in the sixth chapter that Woden, the great Teutonic deity, may be identified with the Celtic Gwydion. The words for law and king are the same in the Celtic and Teutonic languages. Another indication of an early supremacy exercised by the Celts over the ruder tribes to the north of their territory is the noteworthy fact that the Celtic *ambactus*, which denotes a certain magistracy, is found as a loan-word in the Gothic *andbahts*, and also in the Slavonic *jabedniku*. We must thus explain a number of culture words common to Latin and Teutonic as words which originally belonged to the Italo-Celtic unity, which were obtained by the Teutons from the Celts, and this accounts for the curious fact that in political and legal terms Latin is nearer to German than it is to Greek. Thus the Latin *civis* is the Teutonic *hîva*, but has no connection with the Greek πολίτης. The Latin word *hostis* is the Teutonic *guest*, while the Greek word for a stranger is ξένος. The Greeks used the words νόμος and θεσμός for law, while the Latins had *lex*, and the Germans *laga*. The Greeks used the word βασιλεύς for king, while the Latins had *rex*, and the Germans *reika*.*

Latin words of this class, which agree with those in Greek, such as *crimen*, *pœna*, *talio*, manifestly pertain to an earlier and more primitive condition of society.†

Other culture words which the Celto-Italic languages share with Teutonic are the Gothic *thiuds* (people), which is the Umbrian *tutu*, and the Celtic *tuath*; the Latin *ador* (spelt), which is the Irish *ith*, and the Gothic *atisk* (seed). The Latin *far* is the Irish *bairgen* and the Gothic *baris* (barley). The Latin *granum* is our corn; and the Latin *sero* is the Irish *sil*, and the Gothic *saian*.‡

Long ago Niebuhr and O. Müller drew attention to the significant

* Schrader, *Urgeschichte*, p. 75. † *Ibid.*, pp. 78–80. ‡ *Ibid.*, p. 184.

fact that many words relating to husbandry and peaceful avocations, the names for house, field, wood, plow, acorn, apple, fig, wine, oil, salt, honey, milk, dog, ox, bull, calf, sheep, ram, and swine, are identical in Greek and Latin.

It is, however, only the most rudimentary terms connected with agriculture which agree in Greek and Latin. The names for the various species of grain, for the various parts of the plow, for the winnowing fan, for the hand-mill, and for bread, are all different. So also are the words denoting the most elementary legal and political conceptions, as well as the words relating to metals, seamanship, fishing, and war, and the names of weapons, such as *tela*, *arma*, *hasta*, *pilum*, *ensis*, *gladius*, *arcus*, *sagitta*, *jaculum*, *clupeus*, *cassis*, *balteus*, *ocrea*, none of which can be traced in Greek.

Greek, in such matters, has more in common with Sanskrit than with Latin, the Indian and Hellenic words for the spearhead, the sling-stone, the arrow being the same. The name of the axe, πέλεκυς, is peculiar to Greek and Sanskrit. Greek also agrees with Indo-Iranian in the words for the plowshare, the tilled field, the "fork" for digging, the spindle, town, revenge, and punishment, and in the names of three deities. *

We must therefore conclude that the Italic and Hellenic families separated at the very beginning of the agricultural stage, before the most elementary political ideas had been formed; before there was any conception of law, citizenship, or sovereignty; before the bow, the spear, the sword, or the shield had been invented; while the Greeks remained in contact with the Indo-Iranians till the rudimentary forms of the later weapons had been developed.

The Indo-Iranian has several points of cultural contact with the Slavo-Lettic languages, such as the words for the master of house, marriage, holy, noon, cock, bitch, corn, and two divine names, Bogu and Perkunas.

While there is little agreement between Greek and Slavonic, yet the agreement of both with Indo-Iranian is too marked to be the result of accident. It therefore seems probable that the Indo-Iranians remained in contact on the one side with Greeks and on the other with the Slaves for some time after the final separation of Greeks and Slaves.

The Baltic and Indian languages have, however, very few culture words in common. The old Norse *ás*, god, spirit, is the Sanskrit *ásu*, life, which is plainly the primitive meaning. The old High German *ewa*, law, is the Sanskrit *eva*, custom; and the Gothic *hairus*, sword, the Lithuanian *kirwis*, axe, and the Sabine *curis*, spear, are the Sanskrit *çaru*, a thunderbolt.

The Celts share with the Slaves the words denoting winter, silver,

* Schrader, *Urgeschichte*, p. 315.

plow, wheat, beer, yeast, wax, apple, thousand, and some words referring to tillage.

Armenian shares with Greek words for honey, salt, wine, field ; with Lithuanian the name for fish, and with Latin the name of the moon.

The Celts, Albanians, Slaves, and Teutons have all borrowed the Latin *murus*, a sure indication that the art of masonry was obtained from Italy by the Northern nations. The Latin *mina* and the Greek μνᾶ are Semitic loan-words, showing that weights and measures were brought to Europe by the Phœnicians. The Teutonic *pfunt* and *pfeil* are loan-words from the Latin *pondus* and *pilum*, and the Slavonic *chlebu*, bread, is a loan-word from the Teutonic *hlaifs*, loaf

Just as the Finns borrowed countless culture words from the Teutons and Slaves, so the Greeks borrowed no less than a hundred culture words from the Phœnicians.

As a general rule the terms relating to a pastoral life are identical among the European and Asiatic Aryans, whereas the words relating to fixed tillage differ more or less—an indication that the separation of the Indo-Iranian family from the European Aryans took place during the nomad pastoral stage of civilization.

In any case we conclude that the undivided Aryans must have been a numerous people, occupying an extensive territory before any but the rudest civilization was developed, and that the separation began at a time when, like the Tartars at the present day, they roamed in wagons with their flocks and herds over a wide region.

CHAPTER IV.

THE ARYAN RACE.

1.—*The Permanence of Race.*

Our next task is to examine which of the neolithic races has the best claim to be identified with the primitive Aryans.

It is manifest that Aryan blood is far from being co-extensive with Aryan speech. Aryan languages must have extended themselves over vast regions which are occupied by the descendants of non-Aryan races. That this should have been possible is due to the fact that change of language is more easy and frequent than change of physical type.

Broca has insisted on the fact, at one time almost forgotten, that language as a test of race is more often than not entirely misleading. He has rightly maintained that the ethnological characters of the first order of importance are physical, not linguistic.

Mixed races are not so common as is sometimes supposed. They are found, however, in some parts of Europe, especially in England, Normandy, and Central Germany, as is shown by the existence of persons combining blue eyes with dark hair.

It will, however, be impossible to do full justice to the theories of Pösche and Penka, presently to be considered, as to the extension of Aryan speech, without setting forth the reasoning by which they explain the disappearance of intrusive races, and the reversion to primitive types.

It is alleged that in the case of conquest, when two races are diverse, or where the environment favors one race more than the other, it is found that the offspring are infertile, or that there is a tendency to revert to one of the parent types. We get fertile hybrids from different varieties of the dog, or of the pigeon, but not from the dog and the wolf, the horse and the ass, the pigeon and the ringdove.

It is the same with the races of mankind. A mixed race may arise when the parent races do not very greatly differ. But this is not the case when the difference is great. Scherzer says that the child of a European father and a Chinese mother is either altogether European or altogether Chinese. According to Admiral Fitzroy, the half-castes between Europeans and Maoris are unmistakably red, without any tendency to yellow.* The same is the case at Tahiti, where the offspring of French fathers and native mothers are copper-colored.†

A Berber, with blue eyes and no lobule to the ears, married an Arab woman who was brown, and with ears regularly formed. They had two children—one like the father, the other like the mother. An Englishman had several children by a negress, some of whom were of the European, others of the African type. I was much struck with a case I met with at Palermo. A tall, fair, blue-eyed gentleman, of the pure Scandinavian type, had married a short, swarthy, black-eyed Sicilian lady. They had three boys. The eldest was the image of the mother, the youngest of the father, while the second had the eyes and complexion of one parent and the hair of the other.

But even when a half-breed race has come into existence the tendency is to revert to one of the parent types—a tendency which is powerfully aided by environment. At the close of the last century the Griquas, who are half-breeds between the Dutch Boers and the Hottentots, were numerous at the Cape, but as early as 1825 they had practically reverted to the Hottentot type.

Different races do not possess an equal faculty for acclimatization. In the West Indies and the Southern States of North America it is said that the half-breeds between the Anglo-Saxon and negro races tend to become sterile, while the offspring of French or Spanish fathers and negro women are more fertile. Pösche affirms that his

* De Quatrefages, *Hommes Fossiles*, p. 493. † *Ibid.*, p. 494.

own observation, extending over many years, has led him to the conclusion that without an infusion of fresh blood no race of mulattoes has maintained itself to the third generation.* In Jamaica both the whites and the mulattoes become sterile, while the negroes are prolific; and hence the type is lapsing into the pure negro. The European element is dying out, not only through sterility, but by the liability to tropical diseases, which are not so fatal to the natives of the equatorial regions. The English race is doomed to disappear, leaving behind it nothing but a corrupt English jargon as an evidence of its former dominance.

Negroes succeed in the West Indies and the Gulf States, but die out in Canada and New England. The English race succeeds in the Northern States and Australia, but fails in India and the tropics. The Dutch fail to naturalize themselves in Java and Sumatra; and in the third generation even the Malay half-breeds become sterile. The Dutch have left no descendants in Ceylon, but at the Cape they have large families, possessing great stature and physical power. The French succeed in Canada and the Mauritius. In the West Indies and New Orleans they can exist, but they do not increase in numbers. In Algeria emigrants from the Northern Departments of France fail to become acclimatized, while those from the Southern Departments succeed. The Spaniards, a South European race, succeed in Mexico and Cuba, and, together with Maltese and Jews, thrive better in Algiers than any other emigrants from Europe.†

In Egypt no foreign race has ever naturalized itself. The Egyptian fellah still exhibits the precise type seen upon the monuments. The Ptolemaic Greeks have left no trace, the Mamelukes were unable to propagate their race, the Albanians and Turks are mostly childless, and there is great mortality among the negroes.

In India the children of Europeans fade away unless they are sent home before they are ten years old. There is in India no third generation of pure English blood. The Eurasians do not possess the vigor of their fathers, or the adaptation of their mothers to the Indian climate. Hindustan is Aryan in speech, but not in race. There are in India some 140 millions of people who speak Aryan languages, but the actual descendants of the Aryan invaders are very few. They are represented by certain Rajput families, and by the Brahmins of Benares and some other cities on the Ganges.

As a rule it is found that Northern races die out if transplanted to the South, and the Southern races become extinct in the North.

At St. Petersburg the deaths exceed the births, and in North Russia the Slavonic-speaking population only maintains itself owing to the blood being mainly Finnic or Samoyed.

Races become numerically predominant in localities where from

* Pösche, *Die Arier*, p. 10.

† Topinard, *L'Anthropologie*, p. 407.

physical causes the birth-rate is greatest and the death-rate least. The fair race holds the Baltic lands, the brown race the shores of the Mediterranean, and the black race holds the tropics. It is for this reason that intrusive conquest or colonization has usually left little or no trace. The Gothic blood has nearly died out in Spain, the Lombard in Italy, and the Vandal in Northern Africa. Southern Germany was originally Celtic or Ligurian. It was Teutonized in speech by German invaders; the Row Graves of the Alemannic warriors show a mean index of 71.3, and only 10 per cent. of the skulls have an index above 80. But the dolichocephalic type of the Teutonic conquerors has now disappeared from South Germany, and the prehistoric brachycephalic type has reasserted itself, except among the nobles, who are of the Teutonic type. The mean index in the Swabian, Allemannic, and Bavarian lands is now 80. Plainly the fair, northern, dolichocephalic race has been unable to maintain itself, and has left little more than its Teutonic speech as an evidence of conquest.

As a rule the fair races succeed only in the temperate zones, and the dark races only in tropical or sub-tropical lands.

This has been attributed to four causes:

(1) Sterility.

(2) Infantile mortality.

(3) The tendency of an unsuitable climate to enfeeble the constitution so as to prevent recovery from ordinary disease.

(4) The liability to certain special maladies. Pulmonary affections carry off the negroes in the North, while gastric and hepatic disorders are fatal to Europeans in the tropics. Thus, while yellow fever proves deadly to the whites in the West Indies, the negroes escape, and a very slight infusion of negro blood acts as a prophylactic. Negroes succumb readily to the plague, which weeds them out in Egypt, but they enjoy comparative immunity from diseases of the liver. Italians resist malaria better than the English or the Germans.

On the other hand, feeble indigenous races are unable to maintain themselves in presence of the higher civilization of an invading race which happens to be suited to the environment.

In the United States the Red Indians are rapidly disappearing before the whites, while in Mexico the Aztec race shows a continually increasing preponderance over the descendants of the Spanish conquerors. But the Tasmanians, Australians, Maoris, Fijians, and Sandwich Islanders have disappeared or are destined to disappear. The Arabs in Algeria are withdrawing to the Sahara, but the Berbers prosper and increase. The French conquest has resulted in one native race being supplanted by another, just as in the West Indies the European occupation has caused the Carib tribes to disappear before the more vigorous negro race which has been introduced.

These results are partly due to the destruction of former means of subsistence, the former population being unable to adapt itself to new modes of life. The wholesale destruction of the bison and the kangaroo has manifestly accelerated the extermination of the Red Indians and the Australians. The transformation from a hunting to a pastoral life, or from the pastoral to the agricultural stage, cannot rapidly be accomplished. New habits are slowly learned.

But the introduction of new diseases is an important factor in the disappearance of native tribes. The first outbreak of measles carried off nearly half the population of Fiji, and small-pox and scarlatina have elsewhere proved nearly as deadly.

From the foregoing facts it is maintained that hybrid races are not so common as has been often assumed. When two distinct races are in contact they may, under certain circumstances, mix their blood; but the tendency, as a rule, is to revert to the character of that race which is either superior in numbers, prepotent in physical energy, or which conforms best to the environment.

The extreme cases of Hayti and Jamaica may suffice to prove that a dominant race may impose its language on a servile population, and then in the course of two or three centuries may become extinct. These considerations may prepare us to recognize the possibility that Persia, Northern India, and even some parts of Europe may be Aryan in speech, though they may not, to any appreciable extent, be Aryan in blood.

2.—*The Mutability of Language.*

While race is to a great extent persistent, language is extremely mutable. Many countries have repeatedly changed their speech, while the race has remained essentially the same.

Language seems almost independent of race. Neo-Latin languages are spoken in Bucharest and Mexico, Brussels and Palermo; Aryan languages in Stockholm and Bombay, Dublin and Teheran, Moscow and Lisbon, but the amount of common blood is infinitesimal or non-existent.

In France it is probable that nineteen-twentieths of the blood is that of the aboriginal races, Aquitanians, Celts, and Belgæ; while of the later conquerors the descendants of the Teutonic invaders, Franks, Burgundians, Goths, and Normans, doubtless contributed a more numerous element to the population than the Romans, who, though fewer in number than any of the others, imposed their language on the whole country. Again, the speech of Belgium is French—a Neo-Latin dialect; and yet it may well be doubted whether in Belgium there is any Roman blood at all. Coming to Italy, the south is Japygian, Sicanian, and Greek, while the north is Etruscan, Ligurian, Rhætian, Celtic, Herulian, Gothic, and Lombard; while the speech is the speech of Rome, a city which itself contained an overwhelming proportion of Syrians, Greeks, and Africans. The actual amount of Latin blood in Rome was probably extremely small; and yet the speech of Rome extends over Italy, France, Spain, Portugal, Belgium, and Roumania, as well as over a part of Canada and of the United States, and over the whole, or nearly the whole, of Central and South America.

In modern Europe the same struggle for linguistic existence is going on, and the great national languages are exterminating the small isolated tongues. English has replaced Celtic speech in Cornwall, and is encroaching on it in Wales, Ireland, and Scotland. In Brittany the Armorican will speedily become extinct; and in the Basque lands Aryan speech is, as usual, exterminating a non-Aryan language. Basque still survives near St. Sebastian and Durango, but in the neighborhood of Pampeluna and and Vittoria it has already given place to Spanish. Though the French and Spanish Basques speak dialects of the same languages, they belong anthropologically to different races, one of which must have imposed its speech upon the other. The disappearance of the Ladino of the Tyrol, and of the Romansch of the Grisons, is only a question of time.

Within the historic period German has replaced Celtic speech in the valleys of the Danube and the Main, and has more recently extinguished two Slavonic dialects, Polabian, and Wend. The old Prussians spoke a sister language of the Lithuanian; they now speak German. In spite of a strong national sentiment, Hungary and Bohemia are becoming bilingual, and there can be little doubt as to the ultimate result. On the Volga, Russian is exterminating various Finnic languages, such as the Mordwin and the Wotiak. Tartaric speech is disappearing at Kasan and in the Crimea. In America all the aboriginal and local languages are doomed to extinction at no very distant time. English has replaced, or is replacing, Spanish in California, Florida, and Texas, and French in Louisiana. In Lower Canada the French-speaking population is being outnumbered by the English. English is now extending itself over large portions of the globe, as was formerly the case with Latin.

Or look at Mexico. The Spanish conquerors, few in number, succeeded in imposing on the natives their Latin speech, their religion, and their way of life; but the blood is mainly Aztec. After three centuries, the descendants of the Conquistadores are dying out, and the conquest has left its mark mainly in the Latin dialect which has been substituted for the ancient Aztec idiom, and in the allegiance to an Italian bishop.

But these very Spaniards, who have imposed a Latin dialect on so large a portion of the New World, were they Latins, or even Aryans, in blood? Spain was originally Iberian or Berber. In prehistoric times the Celts wrested a large portion of the peninsula from the

Iberians, the Phœnicians founded populous and important cities, the Vandals, Goths, and Suevi poured in from the north, and the Moors and Arabs from the south. The speech, and very little more than the speech, is Latin; the Romans, of whose blood the trace must be extremely small, have imprinted their language upon Spain, and the Spaniards, by reason of their speech, are often reckoned among the Latin races.

The speech of Tunis has been in turn Numidian, Phœnician, Latin, Vandal, and Arabic, and may ultimately become French. In Syria the speech was at first Semitic; it afterwards became Aryan, and is now once more Semitic.

Arabic, the local dialect of Mecca, has become the language of numerous non-Semitic peoples. A host of non-Aryan tribes in India speak neo-Sanskritic languages. The Turks in Candia almost universally speak Greek; at Damascus they speak Arabic. Many of the Papuas speak Malay dialects, and so do the Chinese in Borneo. In Africa languages of the Bantu class are spoken by races as dissimilar as the Caffres and the Guinea negroes. The Huzaras, who are pure Mongols, descendants of the followers of Ghengis Khan, still preserve their marked Mongolian physiognomy, but speak good Persian. The Tschuwash and Bashkirs, who are of Finnic race, speak Turkic dialects.

The Huns who followed Attila have left their name in Hungary, but not their speech. The Gauls who wandered from the banks of the Moselle, and finally settled in Asia Minor, left their name on the province of Galatia, but their language has become extinct. The Bulgars in Dacia acquired the language of their Slavonic subjects.

There is no reason to suppose that the political, social, and religious causes which have brought about such extensive changes of language during historic times, and which have not ceased to operate, were less effective in the prehistoric period. Aryan speech especially seems to possess the power of exterminating non-Aryan dialects. Finnic, Basque, Magyar, Turkish, are gradually but surely being replaced by Aryan languages in Europe. In America, North and South, in South Africa, Polynesia and Australasia, Aryan speech is rapidly extending its domain. Four hundred years ago no Aryan language was spoken on the great American continent; in much less than four hundred years hence there will not, save in the names of places, be a vestige left of any non-Aryan speech. Three thousand years ago the speakers of Aryan languages in India numbered a few thousands; now they number 140 millions. In the neolithic period Aryan languages can hardly have been spoken by more than a million persons. At the present time they are spoken probably by 600 millions—half the population of the globe.

Among the chief causes which have effected such wide extensions of certain languages are slavery, conquest, numerical superiority, commerce, political supremacy, religion, and superior culture. Slaves or serfs readily learn the language of their masters. The negroes in Hayti and the Mauritius speak French ; in Cuba, Spanish ; in Jamaica, English ; in Brazil, Portuguese. In Mexico the pure-blooded Aztecs, who form the larger part of the population, speak Spanish, and so do the Guaranis of Paraguay.

Isolated local dialects are at a disadvantage when in contact with great national languages. To this cause we may attribute the retrocession or extinction of the Wendish and Lettic dialects in Germany, of Finnic dialects in Eastern Russia, of Etruscan, Celtic, and Greek in Italy, of Cornish in England, and of Basque in Spain. Within a measurable period all the Celtic, Euskarian, Finnic, and Turkic languages will have disappeared from Europe, and the whole continent will be Aryan in speech.

In the case of conquest it by no means invariably happens that the language of the conquerors prevails. As in the instances of the Scandinavian conquest of Normandy, of the Norman conquest of England, or of the Roman conquest of Gaul, the conquered country is for a time bilingual, but ultimately one of the two languages must infallibly supplant the other ; usually, however, as we shall presently see, undergoing in the process certain modifications, partly phonetic, and partly in the direction of a simplified grammar.

The Roman conquest of Gaul and Spain, the Mohammedan conquest in Syria, Egypt, and Northern Africa, the Teutonic conquest of Southern Germany, and the Anglo-Saxon conquest of England are the chief instances in which the language of the conquerors has prevailed. But the reverse has been even more frequently the case.

Greek, which was established for a while by the conquests of Alexander as the court language at Antioch, Alexandria, Seleucia, and Samarkand, has now disappeared, leaving nothing but a few coins and inscriptions. The present inhabitants of Greece are largely a Slavonic race, which in the eighth century occupied the lands and learned the speech of the Greeks. There is probably as much of the old Greek blood at Syracuse, Salerno, or Brindisi as in some parts of Hellas. The kingdoms established by the crusading Franks have left behind them only the crumbling ruins of vast fortresses, and perhaps half-a-dozen Western loan-words which have found their way into Arabic. No vestige of Mongolic speech attests the European conquests of Attila or Genghis Khan.

The Bulgars exchanged their own Turkic speech for the Slavonic dialect of their subjects. In Normandy the Northmen acquired French, which in England they exchanged for English. The Franks, the Lombards, the Sueves, the Vandals, and the Goths were unable to impose their Teutonic speech on the Southern lands which they overran. Dr. Hodgkin has described for us the process by which the Gothic language and nationality were extinguished in Italy. The Teutonic invaders were scattered over the land, nominally as paid protectors, really as masters, each receiving what may be designated either as salary or tribute. They became inmates of the Roman homes, enjoying half the house, half of the produce of the vineyard and the farm; they became in most cases the sons-in-law of the Roman citizens whom they protected, but their children were brought up to speak the language of their mothers. Even in Burgundy, where the conquerors were the more numerous race, as is shown by the fact that in the Department of the Doubs the racial type is Teutonic, the speech is now a neo-Latin dialect.

Plainly the laws which regulate the survival of language do not conform to the same conditions as those which regulate the survival of race. The language which prevails in the struggle for existence is sometimes that of the less numerous race, sometimes that of the race which is physically the feebler. It is sometimes that of the conquerors; sometimes it is that of the conquered. Some other law must evidently be sought. The law seems to be that the more civilized race, especially when it is politically dominant, and numerically preponderant, is best able to impose its language on the tribes with which it comes in contact. This law has been thus formulated by Professor Sayce. "We may lay it down as a general rule," he says, "that whenever two nations equally advanced in civilization are brought into close contact the language of the most numerous will prevail. Where, however, a small body of invaders brings a higher civilization with them, the converse is the more likely to happen. Visigothic was soon extirpated in Spain, but English flourishes in India, and Dutch at the Cape. Conquest, however, is not the sole agent in producing social revolutions extensive enough to cause a total change of language. Before the Christian era, Hebrew, Assyrian, and Babylonian had been supplanted by Aramaic. It was the language of commerce and diplomacy."* The influence of a powerful religious belief, especially when enshrined in the pages of a sacred book, has immense influence. The Arabs were inferior in culture to the Roman provincials of Syria, Egypt, and Northern Africa, but the language of the Koran has prevailed.

We may now apply these principles to the spread of Aryan speech in prehistoric times. As the Aryans were probably in most cases numerically fewer than the races whom they Aryanized, we must believed them to have been their superiors in culture as well as in physical force.

The Hellenes when they invaded Greece were undoubtedly more civilized than the non-Aryan aborigines; and the Umbrians were

* Sayce, *Principles of Comparative Philology*, p. 167.

more civilized than the savage Ligurians and the Iberian cannibals whom they found in Italy. The round barrow Aryans of Britain were superior in culture to the feebler long barrow race which they subjugated and supplanted.

The Avesta affords some indications of the struggle between the Iranians and the non-Aryan indigenous tribes on whose territory they encroached; but the Vedic poems supply the best picture we possess of the gradual advance of Aryan speech and culture which must have gone on in other lands.

The Aryan invaders, few in number, who were settled on the banks of the Upper Indus, are found gradually advancing to the south and the east in continual conflict with the Dasyu or dark-skinned aborigines, who spoke a strange language, worshiped strange gods, and followed strange customs, till finally the barbarians are subdued and admitted into the Aryan state as a fourth caste, called the "blacks," or Sudras. The higher civilization and the superior physique of the northern invaders ultimately prevailed, and they imposed their language and their creed on the subject tribes; but the purity of the race was soiled by marriage with native women, the language was infected with peculiar Dravidian sounds, and the creeds with foul Dravidian worships of Siva and Kali, and the adoration of the lingam and the snake.

The Aryanization of Europe doubtless resembled that of India. The Aryan speech and the Aryan civilization prevailed, but the Aryan race either disappeared or its purity was lost.

The rule that it is the more civilized race whose language prevails in the struggle for linguistic existence will incline us to discover the primitive Aryan race in the most civilized of the neolithic races. It is not probable that the dolichocephalic savages of the kitchen middens, or the dolichocephalic cannibals who buried in the caves of Southern and Western Europe, could have Aryanized Europe. It is far more likely that it was the people of the round barrows—the race which erected Stonehenge and Avebury, the people who constructed the pile dwellings in Germany, Switzerland, and Italy, the brachycephalic ancestors of the Umbrians, the Celts, and the Latins, who were those who introduced the neolithic culture, and imposed their own Aryan speech on the ruder tribes which they subdued.

3.—*The Finnic Hypothesis.*

The mutability of language and the permanence of race make it easy to understand that the greater part of Europe may be non-Aryan by blood, but Aryan in speech.

The neolithic races of Europe are so distinct in their anthropological characteristics that only one of them can represent the primitive

Aryan race; the others must be regarded as Aryanized by conquest or contact. The examination of the existing and prehistoric European types has led us to the conclusion that the primitive Aryans must be identified with one of four neolithic races, which, for convenient reference, may be re-enumerated as follows:

(1) The Scandinavians, a tall, Northern, dolichocephalic race, represented by the Row Grave and Stængenæs skeletons and the people of the kitchen middens. The stature averaged 5 feet 10 inches. They were dolichocephalic, with an index of from 70 to 73, and somewhat prognathous, with fair hair and blue eyes and a white skin. They are represented by the Swedes, the Frisians, and the fair North Germans.

(2) The Iberians, a short, Southern, dolichocephalic race, represented in the long barrows of Britain and the sepulchral caves of France and Spain. The stature averaged 5 feet 4 inches, and the cephalic index 71 to 74. They were orthognathous and swarthy. They are now represented by some of the Welsh and Irish, by the Corsicans, and by the Spanish Basques. Their affinities are African.

(3) The Celts, a tall, Northern, brachycephalic race, represented in the round barrows of Britain, and in Belgian, French, and Danish graves. They were macrognathous and florid, with light eyes and rufous hair. The stature was 5 feet 8 inches, and the index 81. They are now represented by the Danes, the Slaves, and some of the Irish. Their affinities are Ugric.

(4) The Ligurians, a short, Alpine, brachycephalic race, represented in some Belgian caves and in the dolmens of Central France. They were black-haired, mostly orthognathous, with an index of 84, and a stature of 5 feet 3 inches. They are now represented by the Auvergnats, the Savoyards, and the Swiss. Their affinities are Lapp or Finnic.

Aryan languages are spoken in Europe by races exhibiting the characteristics of all these types; and in India and Persia by Asiatic types, Dravidian and Semitic, the Aryan blood having been merged in that of conquered races. Hence the primitive Aryans must be sought for among the four European races—Scandinavian, Celtic, Ligurian, and Iberian.

Some thirty years ago a theory which was originally propounded by Retzius, and supported by Baer and Prüner-Bey, was very generally adopted. There are in Europe two races, then believed to be autochthonous—the Finns and the Basques—whose languages do not belong to the Aryan family of speech. Retzius, assuming that both the Finns and the Basques were brachycephalous, and remarking that the Swedes were dolichocephalous, formulated his celebrated "Finnic theory," which long dominated ethnologic science, and is even now not without adherents. He maintained that the primitive population of Europe was a brachycephalic "Turanian" race, the sole survivors of which are now represented by the Finns and Basques. He supposed that this aboriginal population was overwhelmed by dolichocephalic invaders speaking an Aryan language, who are now represented in their greatest purity by the Swedes. These invaders penetrated into Europe from the East, exterminating or enslaving the "Turanian" aborigines, the Basques taking refuge in the Pyrenees, and the Finns in the swamps and forests of the North. This theory has been stated by Professor Max Müller with his habitual lucidity. He informs us that "wherever the Aryan columns penetrated in their migration from the East to the West they found the land occupied by the savage descendants of Tur."*

The "Finnic theory" of Retzius was very generally accepted, but little by little new facts were slowly accumulated, which proved that the proposition of Retzius must be reversed. Broca showed that the Spanish Basques, who are the true representatives of the Basque race, are dolichocephalic, and are not, as Retzius had supposed from an examination of skulls of some French Basques, brachycephalic. De Quatrefages and Hamy then proved that the supposed Aryan invaders were in fact the earliest inhabitants of Europe, and actually possessed a lower culture than the "savage descendants of Tur." The order in which the skulls are superimposed at Grenelle proves that both the dolichocephalic races preceded the two brachycephalic races.† The most ancient skulls of all are those of dolichocephalic savages of the Canstadt and kitchen midden type, who subsisted mainly on shell fish, and must be regarded as the ancestors of the Scandinavian, North German, and Anglo-Saxon race. Next in order of time we find the Iberian race of savages, who subsisted on the chase, and practiced cannibalism and human sacrifice, and whose descendants are found in Corsica, Spain, and Northern Africa. These Iberians were pressed back by the brachycephalic Ligurian race, who arrived in the reindeer period, and are possibly of Lapp affinities. The most recent type of skull is that of the tall, brachycephalic, "Turanian" people of the Finno-Ugric type, who arrived in Belgium and Britain toward the close of the neolithic age. Their civilization was higher than that of any of the previous races. They do not seem to have been troglodytes, but were nomad herdsmen living in huts.

The two "Turanian" races were the last to arrive. The brachycephalic Ligurian race drove the dolichocephalic Iberians to the South and West, and the brachycephalic "Celtic" race drove the dolichocephalic Scandinavians to the North. The result is that

* Broca objects, not unreasonably, to "Tur," and remarks somewhat sarcastically on this passage: "Voici un personage vénérable, qui fut oublié par Moïse, et qui vient s'asseoir aujourd'hui à coté des fils de Noé."—Broca, *La Linguistique et l'Anthropologie*, p. 238.

† See p. 68, *supra*.

Central Europe is brachycephalic, while the North and the South are dolichocephalic. Hence the "Finnic theory," as propounded by Retzius, has been completely overthrown.

The primitive Aryans—that is, those who spoke the primitive Aryan speech—may have been one of the four neolithic races, or they may have been a later intrusive race. The objection to this last hypothesis is that there is no archæological evidence for any such intrusion. The four European types may be traced continuously in occupation of their present seats to the neolithic period; and in the case of the Italic and Swiss pile dwellers, and of the round barrow people of Britain, we must believe that their speech in neolithic times was Aryan—either Celtic or Italic.

We are therefore compelled to adopt the hypothesis that one of the four neolithic races must be identified with the primitive Aryans, and that this race, whichever it was, imposed its Aryan speech on the other three.

We have now to examine in turn the claims of each of the four neolithic races to represent the primitive Aryan stock. The question cannot be considered as determined, the French and German scholars being ranged in opposite camps. All that can be done is to lay impartially before the reader the evidence, such as it is, for forming an opinion. For convenience we may commence with the two short, dark races, the Iberians and the Ligurians, with whom the difficulty is least.

4.—*The Basques.*

The singular Basque or Euskarian language, spoken on both slopes of the Pyrenees, forms a sort of linguistic island in the great Aryan ocean. It must represent the speech of one of the neolithic races—either that of the dolichocephalic Iberians, or that of the brachycephalic people whom we call Auvergnats or Ligurians.

Anthropology throws some light on this question. It is now known that the Basques are not all of one type, as was supposed by Retzius and the early anthropologists, who were only acquainted with the skulls of the French Basques. Broca has now shown that the Spanish Basques are largely dolichocephalic. The mean index of the people of Zarous in Guipuzcoa is 77.62. Of the French Basques a considerable proportion (37 per cent.) are brachycephalic, with indexes from 80 to 83. The mean index obtained from the measurements of fifty-seven skulls of French Basques from an old graveyard at St. Jean de l'Lux is 80.25. The skull shape of the French Basques is therefore intermediate between that of the Auvergnats on the north, and that of the Spanish Basques on the south.

It is plain that the Basques can no longer be regarded as an unmixed race, and we conclude that the blood of the dolichocephalic or

Spanish Basques is mainly that of the dolichocephalic Iberians, with some admixture of Ligurian blood, while the brachycephalic or French Basques are to a great extent the descendants of the brachycephalic Auvergnats.

We have seen that the South of France was, in the early neolithic age, occupied exclusively by the dolichocephalic race. It has been shown that the sepulchral caves and dolmens of the Lozère supply evidence that early in the neolithic period their territory was invaded by the brachycephalic race, which drove them towards the Pyrenees, where the two races intermingled. One race must clearly have acquired the language of the other. The probability is that the invaders, who were the more powerful and more civilized people, imposed their language on the conquered race, in which case the Basque would represent the language of the Ligurians rather than that of the Iberians. All the available evidence is in favor of the solution.

The attempt of Wilhelm von Humboldt* to identify the old Iberian language with the Basque is now generally held to have failed. The highest authority, Van Eys, considers that it is impossible to explain the ancient Iberian by means of Basque. Vinson comes to the same conclusion. He holds that the legends on the Iberian coins are inexplicable from the Basque language, and he considers that they point to the existence in Spain of a race which spoke a wholly different tongue. This tongue belonged probably to the Hamitic family.

We possess some two hundred ancient Numidian inscriptions which exhibit very old forms of the Berber tongue, now spoken by the Towarag and Tamaskek tribes and the Kabyles. These inscriptions suffice to prove that the Numidian belonged to the Hamitic family of speech, and that it is distantly allied to the Nubian and the old Egyptian.† With this Berber or Hamitic family of speech the Basque has no recognizable affinity. Many philologists of repute have come to the conclusion that Basque must ultimately be classed with the Finnic group of languages. Professor Sayce, for instance, considers that "Basque is probably to be added" to the Ural-Altaic family.‡ He says: "With this family I believe that Basque must also be grouped. Prince Lucien Bonaparte, Charencey, and others have shown that this interesting language closely agrees with Ugric in grammar, structure, numerals and pronouns. Indeed, the more I examine the question the nearer does the relationship appear to be, more especially when the newly-revealed Accadian language of Ancient Babylonia, by far the oldest specimen of the Turanian family that we possess, is brought into use for the purposes of comparison." § "In spite of the wide

* Von Humboldt, *Prüfung der Untersuchungen über die Urbewohner Hispaniens.* (Berlin, 1821.)

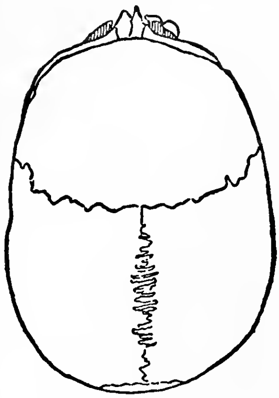
† Sayce, *Science of Language*, vol. ii., pp. 37, 180.

‡ Sayce, *Principles of Philology*, p. 98.

§ *Ibid.*, p. 22.

interval in time, space, and social relations, we may still detect several words . . . which are common to Accadian and Basque."*

These philological conclusions are in accord with the anthropological evidence.



SKULL OF A SPANISH BASQUE.†

The skulls of the pure Iberian race, such as those which are found in the long barrows of Britain, or the Caverne de l'Homme Mort, are of the same type as those of the Berbers and the Guanches, and bear a considerable resemblance to the skulls of the ancient Egyptians. The skulls of the Spanish Basques present a modified form of this type, the cephalic index having probably been raised by admixture with the Ligurian invaders.

We have also seen that the skulls of the Auvergnats, with whom the French Basques must be classed, belong to the Finnic or Lapp type, a fact which increases the probability that the Basque speech, whose affinities are with the Finnic group of languages, represents the primitive speech of the ancient brachycephalic inhabitants of Central France.

But at the beginning of the historic period the speech of these people, the true "Celts" of history and ethnology, differed little from the language of the Belgic Gauls, which we usually call Celtic.

Not to speak of the evidence of inscriptions, this is sufficiently established by Glück's examination of the names of Gaulish chieftains and of local names.‡ Thus in Belgic Gaul we find such names as Noviomagus, Lugdunum (Leyden and Laon), Mediolanum, and Noviodunum; while in the part of Gaul inhabited by Cæsar's Celts we find names either absolutely identical or of the same type, as Noviodunum, Lugdunum (Lyons), Mediolanum (Meillan), and Uxellodunum.

This Southern extension of the language of the Belgic Gauls is no matter for surprise, since the sepulchral caves and dolmens of the Marne and the Oise afford evidence that the Northern race gradually extended its domain to the South.

Aryan speech, as we have seen, possesses in a high degree the power of extirpating languages less highly organized. When the tall, powerful Belgic Gauls extended their dominion over Central France, they would almost inevitably impose what we call "Celtic" speech

* Sayce, *Principles*, p. 108.

† Compare with this the Auvergnat skull figured on p. 111, and the Iberian skull from Gibraltar, on p 123.

‡ Glück, *Die bei C. J. Cæsar Vorkommenden Keltischen Namen.* (München, 1857.)

upon the feebler brachycephalic Basque-speaking Auvergnats, who ethnologically are entitled to the Celtic name.

If so, we should expect to find that the Ligurians, who ethnologically belong to the same race as the Auvergnats, spoke a language of the Basque, and not of Celtic, type. We have only one undoubted Ligurian word, *asia*, which, as we learn from Pliny, denoted, in the speech of the Taurini, grain of some kind, probably rye or spelt, and this word has as yet been only explained from Basque sources.*

Helbig is of opinion that we have an undoubted Ligurian word in the name of Cimiez, near Nice, which was formerly Cimella, or Cemenelum.† The word "Cima," which we have in the name of several Swiss peaks, such as the well-known Cima de Jazi, must have meant a hill. Vestiges of the oldest races are commonly found in the names of mountains, and it is worthy of note that the great mountain mass of Auvergne bears the name of the Cevennes, a corruption of Κέμμενος ὄρος, afterwards known as the Cebenna Mons.

The comparison of local names is beset with uncertainties, but it may be noted that certain names in Liguria, such as Iria, Asta, Astura, and Biturgia, are identical with local names in Spain.‡

Still more notable is Humboldt's failure § to discover in Spain, with the exception of names in *briga*, which may be otherwise explained, any names of the ordinary Celtic type which are so common in Gaul. The conspicuous absence of names ending in *dunum*, *magus*, *lanum*, and *dorum*, looks as if the "Celts" and Celtiberians of Spain did not speak what we call a "Celtic" language.

On the other hand, Celtiberian Spain, which is supposed to have been the district conquered or colonized by the Celts, contains numerous tribe names in *etani*, which is explained as the plural locative suffix in Basque, meaning "those who dwell in" the district designated by the first portion of the name. In Gaul we only find this suffix among the Aquitani, who were the ancestors of the French Basques. That the language spoken by the Aquitani, which must have been an ancestral form of Basque, was actually designated as the "Celtic" speech is indicated by a curious little piece of evidence, which may be taken for what it is worth. The French Basques occupy the same territory as the Aquitani of Cæsar, the corner between the Garonne and Pyrenees. Now Sulpicius Severus, writing in the fourth century A.D., distinguishes between the "Celtic" and "Gallic" speech. A Gaul, he says, speaks *Gallice*, an Aquitanian speaks *Celtice*.‖ Gallic was undoubtedly what we now call "Celtic," while the Aquitani, who lived in a district where "Celtic" has never been spoken, nevertheless spoke

* Diefenbach, *Origines Europææ*, p. 235.

† Helbig, *Die Italiker in der Poebene*, p. 30.

‡ Humboldt, *Prüfung*, p. 111.

§ *Ibid.*, p. 100.

‖ See Penka, *Origines Ariacæ*, p. 106.

what Sulpicius called Celtic, which must be the language which we should call Basque. This would be decisive if it were not for the doubt whether the Aquitania of Sulpicius was co-extensive with the Aquitania of Cæsar, or whether it included the district between the Loire and the Garonne, which was added by Augustus to the older Aquitania for administrative purposes.

It may be as well to sum up briefly the argument set forth in the foregoing pages.

The tall, fair-haired Gauls were of a wholly different type from the short, dark Auvergnats. It is impossible to believe that the language of both races was originally identical, as it had become in the time of Cæsar. One of these races must have imposed its language on the other. Not only were the Belgic Gauls the conquering people, but their language had been extended to Belgium and to Britain, where no traces of the Ligurian race have been discovered. Hence it is most probable that what we call "Celtic" speech was the original speech of the Belgic Gauls, and not of the Auvergnats, the true "Celts" of Broca. Basque must represent either the speech of these true "Celts" or that of the Iberians, as no other neolithic race is found in the Aquitanian region. The race type of the Iberians was that of the Berbers, and their tongue was probably the same—a language of the Hamitic family. Hence we conclude that the language of the "Celts" is now represented by that of the Basques, who, if we may trust Sulpicius Severus, spoke a language which he calls "Celtic."

The Iberians were a feeble race, in a low stage of culture, without cereals or any domesticated animals, and their pottery is of the rudest type. On the coasts of Portugal we find shell mounds resembling the kitchen middens of Denmark, and we discover traces of cannibalism in some of their heaps of refuse. It is not probable that they were able to impose their language on the more highly-civilized Ligurians. We therefore conclude that the language of the Silurian or Iberian race which occupied Britain, Gaul, and Spain at the beginning of the neolithic age was akin to that of the Hamitic race, to which they belong anthropologically, its nearest congener being that of the Numidian inscriptions.

Towards the close of the reindeer period a short, dark brachycephalic race of Finnic or Lapp blood, who are the Ligurians of modern ethnologists and the "Celts" of Cæsar, speaking a Euskarian language, which is believed to belong remotely to the Ural-Altaic class, made their appearance in Western Europe. They found Gaul occupied by a short, dark dolichocephalic people, Silurians or Iberians, who retreated southward to the region of the Pyrenees. Here the Ligurians amalgamated with them to some extent, and imposed on them their language. This mixed race is known as Basque or Celtiberian.

Later in the neolithic age a tall, xanthous, brachycephalic race, belonging to the Ugric type, and speaking an Aryan tongue, which philologists call Celtic, made their appearance in Belgium, north of the Sambre and the Meuse, and gradually drove the Ligurians before them out of Belgic Gaul. Throughout Central France the Ligurians acquired the Aryan speech of their conquerors, while south of the Garonne they retained their own language, which we know as Basque, but which is called Celtic by Sulpicius and Cæsar. Thus of the three neolithic races of Gaul, it seems most probable that the original speech of the Iberians was an Hamitic language, akin to the Numidian; that of the Ligurians was Euskarian, a Ural-Altaic language; while that of the Gauls was Celtic, an Aryan language.

Hence we conclude that neither of the southern races, the Iberians or the Ligurians, can be identified with the primitive Aryans. It remains now to examine the claims to the Aryan name of the two northern neolithic races, the Celto-Latin people of the pile dwellings, and the Scandinavian people of the kitchen middens.

5.—*The Northern Races.*

If, as seems probable, the speech of the Iberians was Hamitic, and that of the Ligurians was Euskarian, neither of these races can be identified with the primitive Aryans. Two possibilities remain to be discussed. The introducers of Aryan speech must have been either the dolichocephalic Row Grave Race, now represented by the Swedes, the Frisians, and the North Germans; or, in the alternative, the brachycephalic round barrow race represented by the Lithuanians, the Slaves, the Umbrians, and the Belgic Gauls.

The question has been debated with needless acrimony. German scholars, notably Pösche, Penka, Hehn, and Lindenschmit, have contended that the physical type of the primitive Aryans was that of the North Germans—a tall, fair, blue-eyed dolichocephalic race. French writers, on the other hand, such as Chavée, De Mortillet, and Ujfalvy, have maintained that the Primitive Aryans were brachycephalic, and that the true Aryan type is represented by the Gauls.

The Germans claim the primitive Aryans as typical Germans, who Aryanized the French, while the French claim them as typical Frenchmen, who Aryanized the Germans. Both parties maintain that their own ancestors were the pure, noble race of Aryan conquerors, and that their hereditary foes belonged to a conquered and enslaved race of aboriginal savages, who received the germs of civilization from their hereditary superiors. Each party accuses the other of subordinating the results of science to Chauvinistic sentiment.

Thus Pösche, in somewhat inflated language, writes: "The true scientific theory, which uplifts itself, calm and clear, like the summit of Olympus, over the passing storm-clouds of the moments, is that a noble race of fair-haired, blue-eyed people vanquished and subjugated an earlier race of short stature and dark hair. In opposition to this is the new French theory, without scientific foundation, originating in political hatred, which asserts that the primitive Aryans were a short and dark people, who Aryanized the tall, fair race." *

M. Chavée, on the other hand, contends that the intellectual superiority lies with the other race. Look, he says, at the beautifully-formed head of the Iranians and Hindus, so intelligent and so well developed. Look at the perfection of those admirable languages, the Sanskrit and the Zend. The Germans have merely defaced and spoiled the beautiful structure of the primitive Aryan speech.

Ujfalvy says: "If superiority consists merely in physical energy, enterprise, invasion, conquest, then the fair dolichocephalic race may claim to be the leading race in the world; but if we consider mental qualities, the artistic and the intellectual faculties, then the superiority lies with the brachycephalic race."

De Mortillet also is strong to the same effect. The civilization of Europe is due, he contends, to the brachycephalic race. †

The disputants seem, however, to have forgotten that neither the French nor the Germans, any more than the English or the Americans, can claim to be an unmixed race. North-eastern France, from Normandy to Burgundy, although of Latin speech, is largely of Teutonic blood, while Central and Southern Germany are occupied by brachycephalic races which have acquired Teutonic speech.

The claimants who have the best pretensions to a pure Aryan pedigree are the dolichocephalic Swedes and the brachycephalic Lithuanians, neither of which have played any very prominent part in history. It is rather the orthocephalic people, found alike in Germany, France, England, and the United States, who, having acquired their physical endowments from the one race, and their intellectual gifts from the other, have reached the highest standard of perfection.

The French cannot claim to be descended from the Gauls any more than the Germans can claim to be descended from the Teutons. When Niebuhr, from the pages of Diodorus and Polybius, described the Gauls who invaded Italy, with their "huge bodies, blue eyes, and bristly hair," ‡ he received a letter from France complaining that he had described, not Gauls, but Germans. In like manner the Teutonic tribes, Alemanni, Suevi, and Franks, who Teutonized Southern Germany, differed altogether from the existing type. In the Row Graves, which are the tombs of these invaders, the mean cephalic index is as low as 71.3. The nobles, descended from these invaders, are still blue-

* Pösche, *Die Arier*, p. 44. † De Mortillet, *Le Préhistorique*, p. 629.

‡ Niebuhr, *Lectures on the History of Rome*, p. 262.

eyed and dolichocephalic; but the burghers and peasants are brachycephalic, with a mean index of 83.5.

In order to determine the affinities of the primitive Aryans we must go back to an earlier time and compare the Row Grave race, who were unmixed Teutons, dolichocephalic and platycephalic, with the round barrow people, who were pure Celts, brachycephalic and acrocephalic.

The types are so different, and can be traced so far back into the neolithic age, that they cannot be identified. One only can be Aryan by blood; the other must be merely Aryan in speech.

On this question experts differ in opinion according to their nationality. The problem is difficult, possibly insoluble. No very confident decision can be given; but the arguments on either side, such as they are, may be placed before the reader.

The German writers urge that the dolichocephalic Swedes, whom they claim as the representatives of the primitive Teutons, are the purest race in Europe, and that it is difficult to suppose that they could have acquired a new language without some admixture of blood, whereas Swedish graves, from the neolithic period down to the present day, exhibit precisely the same type of skull. They moreover contend that, while the peasantry and middle classes over the greater part of Europe are brachycephalic, the nobles and landed proprietors approximate rather to the Teutonic type. This, they say, is a proof that a brachycephalic autochthonous people was conquered and Aryanized by Teutonic invaders.

It has, however, been already shown* that it is not the speech of the conquerors, but the speech of the more numerous and more civilized people that usually prevails; and, in the case of the Normans, the Goths, and the Burgundians, Teutonic conquerors have acquired the speech of the more civilized subject races. This argument cannot, therefore, be considered as conclusive.

Penka has also accumulated a considerable body of evidence, which has already been summarized,† to prove that when a Northern race comes under the influence of Southern skies it tends to die out, and he thus accounts for the fact that there is now no trace in Greece or Italy of the tall, fair, blue-eyed Scandinavian type, which he believes was originally that of the Greeks and Romans as well as of the Persians and Hindus.

Since Penka's theories have met with wide acquiescence in Germany, and have obtained in England the adhesion of such influential scholars as Professor Rendel,‡ Professor Sayce,§ and Professor Rhys,‖

* See p. 122, *supra*.

† See pp. 115–118, *supra*.

‡ Rendel, *The Cradle of the Aryans*, pp. 49, 63.

§ Sayce, *Report of the British Association* for 1887, p. 890.

‖ Rhys, *Race Theories*, p. 4 (*New Princeton Review*, January, 1888).

it is less needful to repeat them at full length than to state the difficulties which must be met, and to examine certain arguments on the other side which, as yet, have hardly received the attention they deserve.

In determining which of the two Northern races has the best claim to represent the primitive Aryans, two kinds of evidence have to be taken into account. One is linguistic, the other archæological.

It will be shown in the next chapter that, when any race abandons its old language and adopts another, the acquired speech is liable to undergo certain changes, both phonetic and grammatical, owing to the difficulty of pronouncing unaccustomed sounds and of learning the niceties of an elaborate grammar. Hence, a language which has lost many of the primitive inflections, and also exhibits extensive phonetic changes, is more likely to be an acquired speech than a language which in these respects has suffered little change.

Judged by this standard the Lithuanian, among European languages, has the best claim to represent the primitive speech. More perfectly, even, than Greek, far more perfectly than Gothic, it has preserved the original inflections as well as the original sounds.

The Teutonic languages, on the other hand, have undergone extensive mutilation. They have lost many of the old inflections which have been preserved in the Slavo-Lettic languages, and more especially in Lithuanian. Gothic has lost the dual, the old ablative, and nearly all the old datives. In conjugation it has lost the aorists, the imperfect, and the future, and has only preserved the present and a very faint trace of the reduplicated perfect. Lithuanian has retained the dual and all the old cases as well as the present and the future, while the South Slavonic has retained the aorists and the imperfect.

In all these points the Slavo-Lettic languages are nearer to the proto-Aryan speech.

The Lithuanian phonology is also the more primitive, as will be seen by comparing the Lithuanian *dalptan* with the Teutonic *delfan*, to delve; *gibanti* with *giban*, to give; *woazis* with *ask*, an ash; *lomiti* with *lam; pulkas* with *folc; klente* with *hrind; kiausze* with *haus; kaistu* with *heito*, *heiz*, and *hot; gladuku* with *glat; tukstantis* with *thusandi* and *thousand.**

If the Teutons are not Aryans by blood, but only Aryanized, how did they acquire Aryan speech? Geographically they were hemmed in by the Celts and the Lithuanians. The relations between Celtic and Teutonic speech are not so intimate as to make it probable that either could have been derived from the other. But with the Lithuanian it is different. The Lithuanians belong to the great brachycephalic race, the Teutons to the dolichocephalic. The two races are,

* See Schmidt, *Verwandtschafts verhältnisse der Indo-Germanischen Sprachen*, pp. 36–45.

and as far as we know have always been, in geographical contact, and Teutonic speech is nearer to Lithuanian than to any other Aryan language. According to Penka's theory, the ancestors of the Lithuanians acquired Aryan speech from the ancestors of the Teutons; according to the other theory, the ancestors of the Teutons acquired it from the ancestors of the Lithuanians.

It is difficult to believe that the Teutonic, which has lost so many of the primitive inflections, which has mutilated so many Lithuanian words, and has degraded the primitive phonology, can represent the mother speech from which Lithuanian was derived; whereas there is no such insuperable difficulty in supposing that Teutonic may have been obtained from some older form of Slavo-Lettic speech. Moreover, on Penka's hypothesis, a still greater difficulty has to be met. It will have to be explained how the speech of the brachycephalic Celts and Umbrians, to say nothing of that of the Greeks, the Armenians, and the Indo-Iranians, was obtained from that of the dolichocephalic Teutons; how a people which in neolithic times was few in numbers, and in a low state of culture, succeeded in Aryanizing so many tribes more numerous and more civilized.

We have now to consider the other department of the evidence—the evidence of archæology and of linguistic palæontology. We have already seen* that the general law is that, when two races in different stages of culture are in contact, the speech of the more cultured is likely to prevail in the struggle for linguistic existence. This rule has a most material bearing on the question. If with Penka we are to believe that the Teutons were by blood the only pure Aryan race, which Aryanized all the rest, their relative culture should be high. But, if we go back to the early neolithic period, the time when, if at all, the Teutons must have imparted Aryan speech to the other race, we find that the dolichocephalic people of the Baltic coast were in the lowest grade of savagery, while the brachycephalic races of Central Europe had made no inconsiderable progress in civilization, and had reached the nomadic pastoral stage.

Coming down to a much later period, we find that at the close of the neolithic age the Teutonic race was the more backward, since their culture words are largely loan-words from the contiguous Slavo-Lettic and Celtic languages. This is the case even with words referring to agricultural and pastoral life.

As M. d'Arbois de Jubainville and other writers have shown, Celtic, in its fundamental morphological structure, is more closely related to Latin than it is to Teutonic. The relations between Celtic and Teutonic date from a comparatively late period, and are valuable as showing the relative civilization which had been attained by both peoples. Several Celtic loan-words which have found their way into Teutonic

* See p. 122, *supra*.

relate to matters of civil and military administration. They can hardly be later than the time of the Gaulish empire founded by Ambigatos in the sixth century B.C. We gather from them that at this, or some earlier period, the culture and political organization of the Teutons was inferior to that of the Celts, and that the Teutons must have been subjected to Celtic rule. It would seem, from the linguistic evidence, that the Teutons got from their Celtic and Lithuanian neighbors their first knowledge of agriculture and metals, of many weapons and articles of food and clothing, as well as the most elementary, social, religious, and political conceptions—the words for nation, people, king, and magistrate being, for instance, loan-words from Celtic or Lithuanian.

The hypothetical Aryanization of Europe by Teutonic conquerors which Penka's theory demands must be referred to a very remote period, long before the rudiments of civilization had been imparted to the Teutons by contact with the more civilized Celts. It is difficult to suppose that the Teutons, several millenniums before they had acquired the conception of sovereignty, of a nation, of an army, or of a state, could have Aryanized by conquest the ancestors of peoples so much more advanced in social organization and the arts of life as the Indians and the Iranians, or the Homeric Greeks andt he people of Mycenæ and Tiryns.

These hypothetical Teutonic conquests must have taken place very early in the neolithic age, or how can we explain the Aryan speech of the Celts and Umbrians, who erected Stonehenge and Avebury, and constructed the lake dwellings in Southern Germany, Switzerland, and Italy?

We must inquire whether at so remote a time the dolichocephalic people of the Baltic coasts had arrived at a stage of civilization which would make it probable that they could have conquered and Aryanized all the brachycephalic Southern races.

We learn from the science of linguistic palæontology that the undivided Aryans were a neolithic people, who had reached the pastoral stage, and may have practiced some rude form of sporadic agriculture. It is certain that they had domesticated the ox, and probably the sheep, following their herds in wagons, and constructing huts with roofs and doors; but they were probably unacquainted with the art of catching fish, which they did not habitually use for food.

With this linguistic evidence as to the grade of civilization attained by the undivided Aryans, we may compare the archæological evidence as to the civilization of the neolithic ancestors of the Teutons and the Celts.

It has already been shown that the neolithic people of the shell mounds of Sweden and Denmark represent the ancestors of the Scandinavians and Teutons, while the neolithic people of the pile dwellings of Southern Germany, Switzerland, and Northern Italy are to be identified with the brachycephalic ancestors of the Celto-Latin race.

At the earliest period to which our knowledge extends the valley of the Danube was occupied by dolichocephalic savages of the Canstadt race, who sheltered themselves in caves. They were replaced, in the early neolithic age, by the brachycephalic people whose remains are found in the mound graves of this region, and who are believed to belong to the same race as the round barrow people of Britain. To this race the pile dwellings must be assigned. In the peat bogs and lakes of Carniola, Austria, Bavaria, Würtemberg, and Baden, we find the remains of pile dwellings which are the prototypes of the later pile dwellings of Switzerland and Northern Italy, and which to all appearance were constructed by races essentially the same, who extended eastward to Dacia and Thrace. According to Herodotus, there were pile dwellings in Lake Prasias, in Thrace. The Dacians were an Aryan people, akin both to Thracians and Celts, and a representation of a Dacian pile dwelling may be seen on Trajan's column at Rome.* Remains of pile dwellings, belonging to the neolithic age, have also been found in the Lithuanian region. The practice of erecting pile dwellings seems therefore to have been common to the Aryan-speaking peoples of Central Europe.

One of the oldest pile dwellings hitherto discovered, coeval it is believed, with the Danish shell mounds,† has been disinterred from a peat moss at Schussenried, on the Feder See, in Würtemberg. The stage of culture here disclosed is precisely that which linguistic archæology proclaims to have been possessed by the primitive Aryans. The people lived mainly by the chase. The bones of the stag are more plentiful than those of any other animal, but those of the wild boar are common. The dog, the ox, and the sheep had been domesticated, but no bones of the goat or of the horse have as yet been found. The implements were of stone, horn, and bone. Mealing stones were found, and charred wheat, but cereals are less abundant than stores of hazel nuts, beech mast, and acorns. Linseed was found, but no linen, the only fabric being a bit of rope made of twisted bast. It is to be noted that no fishing implements of any kind were discovered; there were a few vertebræ of a pike, but the extreme rarity of fish bones is remarkable.

Remains of a somewhat later settlement exist in the Lake of Starnberg, in Bavaria. Here the bones of the dog, the ox, the sheep, and the goat are numerous, together with hazel nuts and barley.

It will be noticed that the civilization disclosed in these settlements, and in some similar ones on the northern shore of the Lake of Constance, agrees very remarkably with that of the primitive Aryans.

* Helbig, *Die Italiker in der Poebene*, p. 56.

† Keller, *Lake Dwellings*, vol. i., p. 589.

Older probably, if we may judge from the absence of cereals, is the very ancient lake dwelling which has been disinterred from the peat bog on Laibach Moor, in Carniola, about fifty miles northeast of Trieste.* That this region was occupied by a Celtic-speaking people is indicated by the fact that the moor is intersected by a river which bears the common Celtic name of the Isca, which was also the ancient name of the Devonshire Exe and the Monmouthshire Uxe. The inhabitants of this settlement were in the pastoral stage ; they possessed cows, sheep, and goats, but lived principally by fishing and the chase, their food consisting chiefly of the flesh of the stag and the wild boar. They cultivated no cereals, but laid up stores of hazel nuts and water chestnuts (*Trapa natans*), which they pounded in stone mortars. They were in the neolithic stage, the implements are chiefly of stags' horn, the stone implements are rude, not superior to those of Denmark. They were wholly ignorant of agriculture ; neither grain, flax, nor linen, which are common in the Swiss settlements, have been found. The only woven fabric yet discovered was a piece of bast matting, manufactured from the bark of some tree.

The Laibach settlement was not abandoned till the age of metal had begun, a store of copper or bronze implements having been discovered on one spot—a fact which connects the settlement with the historical occupation of this region by the Latovici, who, according to Zeuss, were Celts.†

By this route, through Carniola, which forms the easiest passage across the Alps, the Umbrians, the near congeners of the Celts, may have penetrated into Italy. The other route, by the Brenner, was occupied by the Rhætians, who were probably of Ligurian race.

The Celts of the British round barrows and of the Belgian caves were in much the same grade of civilization as the Celts of the earlier pile dwellings.‡ The round barrows of the stone age were the sepulchres of a pastoral people, who had domesticated the ox, the sheep, the goat, and the pig.§ Though no remains of corn have been discovered, the mealing stones, which are not uncommon, are believed to prove that they used cereals of some description.‖ In all essential points, the civilization of the neolithic Celts of Britain was identical with that of the undivided Aryans as disclosed by linguistic archæology.

We now turn to the people of the Danish shell mounds, who belonged to the tall dolichocephalic type now represented by the North Germans and the Swedes. This type has been so confidently identified by recent German writers—Lindenschmit, Penka, and Pösche—with that of the primitive Aryans, that the question of the grade of civilization which they had attained has become an important factor in the discussion as to the ethnic affinities of the Aryans.

* Keller, *Lake Dwellings*, vol. i., pp. 606-618. † Zeuss, *Die Deutschen*, p. 257.
‡ Greenwell, *British Barrows*, p. 114. § *Ibid.*, pp. 168, 130, 132. ‖ *Ibid.*, p. 114.

The vast mounds called *Kjækkenmœddings*, which line portions of the Danish and Swedish coasts, have already been described.* They are manifestly the refuse accumulated during long ages by a race of savages. They are composed chiefly of the shells of oysters and other mollusks, but contain also numerous bones of wild animals, of birds, and of fish. Implements of stone are numerous; they are mostly rude, but in some instances carefully worked. Bone pins and implements of horn are found; but pottery, so abundant even in the oldest lake dwellings, is extremely rare. The rudeness of the stone implements and the rarity of pottery show that during the immense period required for the accumulation of these mounds the people who formed them had made little progress in the arts of life.

We now apply to these mounds the same linguistic tests which have been applied to the lake dwellings. They contain bones of the stag, the beaver, the bear, the otter, the hedgehog, the lynx, the fox, and the wolf, all of which, according to Schrader's linguistic investigations, were known to the primitive Aryans. This, however, is not decisive, since the bones of the horse, the hare, and the squirrel, animals also known to the undivided Aryans, are absent. Still more important is the absence of the bones of animals which, on linguistic grounds, are believed to have been domesticated before the separation of the Aryans. There are no remains of the goat, the sheep, or even of the ox, but only a few bones of the urus, which doubtless belonged to the wild animal, slain in the chase. The absence of the bones of the reindeer, which are found in the caves of the brachycephalic people of the Lesse, is an evidence of the comparatively recent date of the kitchen middens, and may also indicate that the Lapps had already retired farther to the North.

The only animal that had been domesticated was the dog, who was occasionally eaten when other food was scarce. The domestication of the dog has been established by Professor Steenstrup, who, as we have already seen, found by experiment that certain bones of birds, and certain portions of the bones of quadrupeds, which are invariably absent from the refuse heaps, are precisely those which are eaten by dogs, while those bones which do occur are those which dogs habitually reject.†

Now, the evidence of the Stængenæs skull identifies the kitchen midden people with the Scandinavian race, while the earlier pile dwellings are believed to be as old as some of the kitchen middens. The stage of civilization disclosed by the earlier pile dwellings agrees with that which on linguistic grounds we must attribute to the undivided Aryans, while the civilization of the kitchen middens was far ruder; not higher than that of the Fuegians or of the Digger Indians of Oregon.

* See p. 35, *supra*. † Lubbock, *Prehistoric Times*, p. 240; and see p. 130, *supra*.

Virchow, Broca, and Calori agree that the brachycephalic or "Turanian" skull is a higher form than the dolichocephalic. The most degraded of existing races, such as the Australians, Tasmanians, Papuas, Veddahs, Negroes, Hottentots, and Bosjemen, as well as the aboriginal forest tribes of India, are typically dolichocephalic; while the Burmese, the Chinese, the Japanese, and the nations of Central Europe are typically brachycephalic. The fact that the Accadians, who belonged to the Turanian race, had, some 7,000 years ago, attained a high stage of culture, from which the civilization of the Semites was derived, is a fact which makes it more probable that the language and civilization of Europe was derived from the brachycephalic rather than from the dolichocephalic race.

There was an essential difference in the mode of life of the two races. The Aryans, before the linguistic separation, were a pastoral people, who had invented the ox-wagon, and had therefore certainly domesticated the ox, but were unacquainted with the art of fishing, since the words for the net, the line, the hook, and other fishing implements differ in most of the Aryan languages; while fish-bones and hooks are absent from the older pile dwellings in Germany and Italy. The kitchen midden people, on the other hand, had not domesticated the ox, but subsisted chiefly on oysters, muscles, cockles, and periwinkles, varied by the products of the chase. They were, however, very skillful fishers, as the bones of the herring, the dorse, the dab, and the eel are extremely numerous in all the shell mounds. If the Aryans are descended from the kitchen midden people, it is difficult to understand how they should have lost the taste for fish, or have relinquished their chief art—that of the fisherman.

It is not less difficult to believe that the repulsive savage of the kitchen middens, with his narrow brow, his retreating forehead, his low skull, his prognathous jaw, his prominent orbital ridges, and his animal propensities so clearly indicated by the occipital development—a mere nomad hunter, without fixed abode, and making use of no regular sepulchres—could have been the ancestors of the noble Aryan race. It is easier to believe that the Aryan civilization originated with the broad-headed race of Central Europe, which possessed the skill to construct, with rude stone tools, the pile dwellings of Switzerland and Italy.

It may be urged that the two civilizations were not synchronous, and that the accumulation of the shell mounds ceased long before the earliest of the pile dwellings were erected. This, however, does not seem to have been the case. The two periods are believed to have overlapped for some two or three thousand years, while the types of the flint implements found in the lake dwellings at Schussenried are thought to be more archaic than some of those from the kitchen middens.* Moreover, there are reasons for believing that the mode of

* Keller, *Lake Dwellings*, vol. i., pp. 584, 589.

life of the shell mound people lasted down to the historic period. Virchow, as we have seen,* claims to have discovered the descendants of the ancient Frisians in the platycephalic inhabitants of certain islands in the Zuyder Zee, whose skulls are of the low Neanderthal type. It must be the inhabitants of these islands who are described by Cæsar as the fierce barbarians who lived at the mouth of the Rhine, and subsisted on fish and the eggs of birds.†

If these islanders were, as Virchow maintains, the ancestors of the Frisians, whose language preserves an archaic form of Teutonic speech, we must believe that they were an isolated survival of the pure Teutonic race. In their skull form they agree more nearly with the Swedes than with any other European race; while their manner of life in Cæsar's time corresponds to that of the people of the kitchen middens, whose skulls are also of the dolichocephalic Swedish type. But if in Cæsar's time these fish-eating Frisian coast tribes were still mere savages, it is hardly possible to identify them with the primitive fish-loathing Aryans, who, before the linguistic separation, had reached the pastoral stage, had domesticated the ox, if not also the sheep; and who had invented the ox-wagon, in which they traveled as their herds moved in search of pasture.

We have already seen that, when two races are in contact, the probability is that the speech of the most cultured will prevail. It is an easier hypothesis to suppose that the dolichocephalic savages of the Baltic coast acquired Aryan speech from their brachycephalic neighbors, the Lithuanians, than to suppose, with Penka, that they succeeded in some remote age in Aryanizing the Hindus, the Romans, and the Greeks.

Physically the Teutonic race is taller, larger-limbed, and more powerful than any other. The Swedes, their purest representatives, are the tallest race in Europe, averaging 5 feet 7½ inches in height. The Stængenæs man reached 5 feet 10 inches. The Scandinavian skeleton found at Aspatria in Cumberland must have been 7 feet in stature. Sidonius Appolinaris also describes the gigantic Burgundians as 7 feet high. But the skull is of a low type. The index of the Engis skull is 70.52, of the Hohberg type, which represents the Burgundian conquerors of Switzerland, 70.07; of the Row Grave type, 71.3; while the descendants of the Frisians have a lower cranial vault than any other European race.

The pure Teuton is phlegmatic in temperament, and somewhat dull of intellect; but is brave, warlike, and given to field sports and

* See chapter ii., section 6.

† Describing the Rhine, he says: "Ubi Oceano appropinquat, in plures diffluit partes, multis ingentibusque insulis effectis, quarum pars magna a feris barbarisque nationibus incolitur (ex quibus sunt, qui piscibus atque ovis avium vivere existimantur), multisque capitibus in Oceanum influit."—Cæsar, *De Bello Gallico*, iv., 10.

athletic exercises. He is a tall, flaxen-haired, large-limbed giant, fat and stupid, like the Goths and Burgundians, whom the Roman provincials regarded with fear, mingled with contempt.

It is a result of Teutonic conquest that the landed gentry of Europe are largely descended from this race—Goths, Lombards, Normans, Franks, Saxons, Angles—and they preserve with singular persistency the physical characteristics and the mode of life of their remote ancestors. It is, as an acute writer has remarked, "a strange result of the wealth and intelligence of the modern world to give the upper classes the pursuits of the savage, without the necessity which is the excuse for them. They are barbarians armed with the complicated appliances of civilization. Their greatest glory is to have killed a large quantity of big wild beasts." "Field sports are good for keeping up the energy of semi-barbarous aristocracies." *

Matthew Arnold's fair-haired "young barbarians," cricketers, deer-stalkers, or fox-hunters, but destitute of intellectual tastes, are noble types of the Teutonic race, but they are not the "children of light." Owing to their strength, bravery, and stature, the Teutons have been a great conquering race, but the Goths and their kinsmen had not the genius to rule the kingdoms they had won. The Saxons, the Angles, the Goths developed no high civilization of their own. The Scandinavians and Frisians have little intellectual culture. The genius of Germany comes from the other race, to which Luther and Goethe both belonged. "Philippus Zaehdarm, Zaehdarmi Comes, qui quinquies mille perdrices plumbo confecit," was a representative of one race, Teufelsdröckh and his biographer of the other.

The qualities which have enabled the Teutonic races to play their wonderful part in the history of Europe are well displayed in the twelve valiant sons of Tancred of Hauteville—William Iron Arm, Robert Guiscard, Roger, and the rest—who carved out kingdoms for themselves in Apulia and Sicily. They were a vigorous race, large of limb, stout of heart, tenacious in will, with abundant physical energy, taking their pleasure in drinking and hunting. They had broad shoulders, fair hair, and blue eyes, as we see from Anna Comnena's portrait of the son of Robert Guiscard, Bohemond, Prince of Tarentum, who was "a cubit taller than the tallest man known, fair, with blue eyes, his cheeks tinted with vermilion."

The energy, the self-will, the fondness for adventure, and the love of combat which have enabled the Teutonic peoples to extend their rule over the world, come from the dolichocephalic race; but the intellect and genius of Europe, the great writers, and more especially the men of science, belong rather to the brachycephalic race, which has so profoundly modified the physical type in Germany, France, Italy, and England.

* Hamerton, *French and English*, pp. 61, 265.

Pösche and Penka* have drawn attention to the curious fact that, though the lines of linguistic demarkation in Europe have small relation to race, the religious division adheres very closely to the racial frontiers. The reason they assign is that religion depends more intimately than language on the fundamental ethical character of the race. No European nation is Mohammedan, or even any Aryan nation, except to some extent the Persians, and in Persia we find only the Shiah sect, which has altogether transformed the innermost tenets of Islam. The Shiahs are essentially mystics, and they have found themselves able to read into the Koran doctrines which approximate very curiously to those of Swedenborg, Tauler, and other Teutonic mystics.

The Jews speak everywhere the language of the land in which they sojourn, but everywhere they have clung tenaciously to the doctrines of their Oriental faith. And so the Christianity of the New Testament, with its peacefulness, its submissiveness, and its resignation, in which it agrees with Islam and other Oriental faiths, was contrary to the inner genius of the Teutonic race, with its independence, its self-will, its free life, and its contentiousness. Hence the Teutonic races, in which these Aryan characteristics are the most strongly developed, were the last to submit to the yoke of the Gospel. It was only when the Goths had settled within the bounds of the Roman Empire that they were converted, and when they were converted it was to a rationalistic form of Christianity; it was Arianism and not Catholicism which they were willing to accept.

And, now that Christianity has spread over Europe, it is divided into two opposed camps—the Catholic and the Protestant, the Church of Authority and the Church of Reason, the line of division coinciding very closely with the line which separates the two great races of Aryan speech. The dolichocephalic Teutonic race is Protestant, the brachycephalic Celto-Slavic race is either Roman Catholic or Greek Orthodox. In the first, individualism, willfulness, self-reliance, independence are strongly developed; the second is submissive to authority and conservative in instincts. To the Teutonic races Latin Christianity was never congenial, and they have now converted it into something very different from what it was at first, or from what it became in the hands of Latin and Greek doctors. The Teutonic peoples are averse to sacerdotalism, and have shaken off priestly guidance and developed individualism. Protestantism was a revolt against a religion imposed by the South upon the North, but which had never been congenial to the Northern mind. The German princes, who were of purer Teutonic blood than their subjects, were the leaders of the ecclesiastical revolt. Scandinavia is more purely Teutonic

* The following pages are little more than a summary of the somewhat speculative remarks of these writers. See Pösche, *Die Arier*, p. 210; Penka, *Origines Ariacæ*, p. 115.

than Germany, and Scandinavia is Protestant to the backbone. The Lowland Scotch, who are more purely Teutonic than the English, have given the freest development to the genius of Protestantism. Those Scotch clans which have clung to the old faith have the smallest admixture of Teutonic blood. Ulster, the most Teutonic province of Ireland, is the most firmly Protestant. The case of the Belgians and the Dutch is very striking. The line of religious division became the line of political separation, and is conterminous with the two racial provinces. The mean cephalic index of the Dutch is 75.3, which is nearly that of the Swedes and the North Germans; the mean index of the Belgians is 79, which is that of the Parisians. The Burgundian cantons of Switzerland, which possess the largest proportion of Teutonic blood, are Protestant, while the brachycephalic cantons in the east and south are the stronghold of Catholicism. South Germany, which is brachycephalic, is Catholic; North Germany, which is dolichocephalic, is Protestant. Hanover, which is Protestant, has a considerably lower index than Cologne, which is Catholic. The Thirty Years' War was a war of race as well as of religion, and the peace of Westphalia drew the line of religious demarkation with tolerable precision along the ethnic frontier.

Wherever the Teutonic blood is purest—in North Germany, Sweden, Norway, Iceland, Ulster, the Orkneys, the Lothians, Yorkshire, East Anglia—Protestantism found easy entrance and has retained its hold, often in some exaggerated form. In Bohemia, France, Belgium, Alsace it has been trodden out. In Galway and Kerry it has no footing. The Welsh and the Cornishmen, who became Protestants by political accident, have transformed Protestantism into an emotional religion which has inner affinities with the emotional faith of Ireland and Italy. Even now Protestantism gains no converts in the South of Europe, or Catholicism in the North. Roman Catholicism, or the cognate creed of the Greek and Russian orthodox churches, is dominant in all those lands where the brachycephalic race prevails; Protestantism is confined to the dolichocephalic Teutonic region. The neighborhood of Toulouse, which was the headquarters of the Albigenses, is more dolichocephalic than any other part of Southern France, and Toulouse was the Visigothic capital. In no city of France were the Huguenots so numerous as at Nîmes, another stronghold of the Visigoths, and Nîmes is still largely Protestant in creed. England, which is orthocephalic, is neither Catholic nor Protestant, but Anglican. It is not to be supposed, however, that religious belief is a function of the shape of the skull, but that the shape of the skull is one of the surest indications of race.

Those who are curious in such matters may refer to Cæsar's contrast between the religions of the Germans and of the Gauls.* The

* Cæsar, *B. G.*, Bk. vi., cap. 13 and 21.

same essential contrast in the religious genius of the two races prevailed then as it does now. The Gauls had a Pope. "His autem omnibus Druidibus præest unus, qui summam inter eos habet auctoritatem." The priests are judges in public and private concerns, and disobedience to their decrees is followed by an interdict. "Si qui aut privatus aut publicus eorum decreto non stetit, sacrificiis interdicunt. Hæc pœna apud eos est gravissima. Quibus ita est interdictum, ii numero impiorum ac sceleratorum habentur; iis omnes decedunt aditum eorum sermonemque defugiunt: ne quid ex contagione incommodi accipiant; neque iis petentibus jus redditur, neque honos ullus communicatur."

This might be taken as a picture of a Roman interdict in the Middle Ages, or even of modern boycotting in Ireland.

With this we may compare the picture of the religion of the Germans: "Germani multum ab hac consuetudine [Gallorum] differunt; nam neque Druides habent, qui rebus divinis præsint, neque sacrificiis student."

CHAPTER V.

THE EVOLUTION OF ARYAN SPEECH.

1.—*The Aryan Languages.*

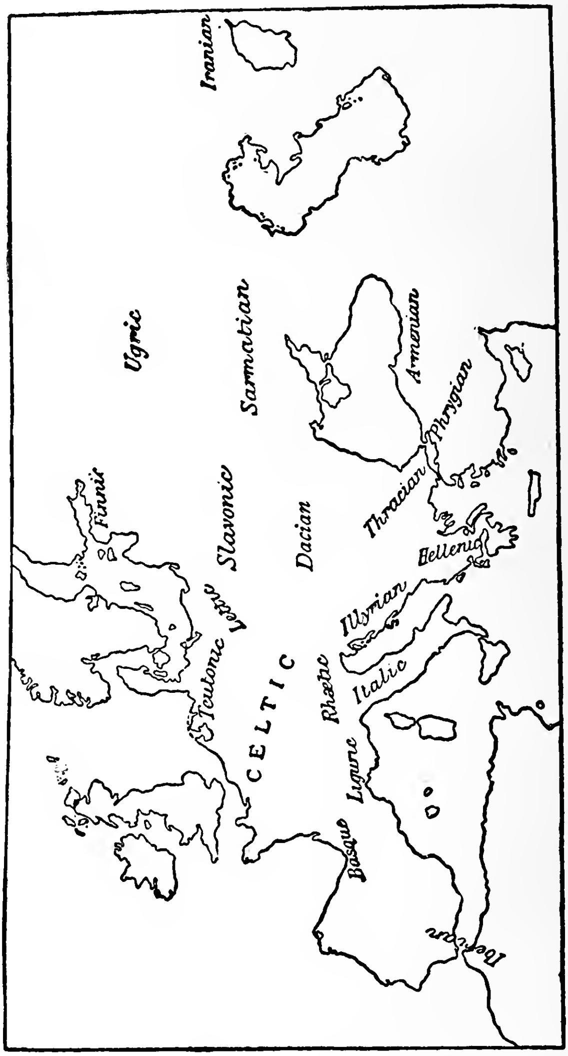
FORTY years ago it was believed that relationship of language implied relationship of blood, and it was the fashion to talk of the Aryan family and the Aryan race.* The pendulum then swung in the opposite direction, and Oppert lays it down that "there are Aryan languages, but there is no Aryan race." It may be questioned whether the reaction has not gone too far. It may be admitted that the word "Aryan" should be primarily regarded as a linguistic rather than as an ethnic term, and that though the Aryan languages may be traced to a common source, the speakers of those languages have for the most part no community of blood. But since Aryan speech must have originated with some one of the races among which it now prevails, it is legitimate to inquire by which of them it was probably evolved.

The undivided Aryans doubtless roamed as nomad hunters and herdsmen over a considerable territory, gradually multiplying in number and incorporating other tribes. The modifications of the primitive speech are believed to be largely due to the acquirement of Aryan speech by these non-Aryan races.

From anthropological and archæological considerations we have

* See p. 2, *supra.*

seen that of the four neolithic races of Europe two must be excluded from any claim to represent the primitive Aryans, and that of the remaining two the balance of evidence inclines in favor of the brachycephalic race of Central Europe. The linguistic evidence has now to



be taken into account, and we have to consider the mutual relations of the Aryan languages, to ask how they became differentiated, how the primitive Aryan speech could have been evolved, and whether it could have been the speech of that race which, on other grounds, seems to have the best claim to represent the primitive Aryan stock.

There are nine existing families of Aryan speech—the Indian, the Iranian, the Armenian, the Hellenic, the Italic, the Celtic, the Teutonic, the Lithuanian or Lettic, and the Slavic. Besides these there are several which have become extinct, such as the Phrygian, the Dacian, and the Thracian.

Some of the more closely-related families may be grouped together, giving six families instead of nine—the Indo-Iranian, the Armenian, the Hellenic, the Celto-Italic, the Teutonic, the Letto-Slavic.

Zend and Sanskrit are so closely allied that we may postulate the existence of a common mother-tongue for both, which, for convenience, we may call the Indo-Iranian. In like manner, Lithuanian is closely related to Slavonic on the one hand, and less closely to Teutonic on the other.

The old traditions of classical philology, dating from a time when only two ancient Aryan literatures were known, gave rise to a belief that the two classical tongues, Greek and Latin, were sister languages, very closely allied ; but this opinion has now given place to the belief that the closest affinities of the Italic languages are with Celtic, and those of Greek with Indo-Iranian and Armenian.

Schmidt catalogues ninety-nine words which occur only in Greek and Indo-Iranian, and one hundred and thirty-two which are found only in Greek and Latin. Some of these, however, are culture words, or the names of animals and plants, which may probably not be primitive. Of more importance is the fact that the augment and the reduplicated aorist are confined to Greek and Indo-Iranian, while they also possess peculiar forms of the infinitive. The names of six Greek deities can be explained from Sanskrit, while only three are common to Greek and Latin.

We have seen* that, while certain words relating to the pastoral life, and to rudimentary agriculture, are common to Greek and Latin, the names of weapons differ, the Greek names agreeing for the most part with Sanskrit, and the Latin names with Celtic. The relative dates of the linguistic separations are also indicated by the numerals. The undivided Aryans could only count up to a hundred. The word for a thousand is common to Greek and Indo-Iranian, but is not shared by Latin. Latin and Celtic have the same word for a thousand, and so have Lithuanian and German. We conclude, therefore, that the separation of Greek and Latin, and of Latin and Lithuanian, was comparatively early ; but that the separation of Latin and Celtic, of Greek and Indo-Iranian, of Lithuanian and German, was comparatively late.

On other grounds it appears that the Italic languages are much more intimately related to Celtic than to Greek. The Umbrians, the

* See p. 113, *supra*.

northernmost of the Italic peoples, were in geographical contact with the Celts, but must have been separated from the Hellenes by the Illyrians. The Thracian and Dacian languages, which are lost, probably formed links between Greek and Celtic.

Bacmeister,* by the aid of local names, has traced the ancient domain of Celtic speech. It included the valleys of the Rhine, the Main, and the upper Danube, together with Belgium, Britain, and portions of Switzerland and France. Celtic territory formed the great central region of Aryan speech. It extended on the east to the frontiers of Dacia, if indeed Dacian was not itself a member of the Celtic group.

Lugdunum, a characteristic Celtic name, is found at Laon, at Leyden on the lower Rhine, at Lyons on the Rhone, and on the upper Garonne at the foot of the Pyrenees. We find Batavodurum at the mouth of the Rhine, and Boiodurum at the junction of the Danube and the Inn.

That Southern Germany, before it was Teutonized by northern conquerors, was occupied by the Celts is proved by the Celtic names in the valley of the Danube and even of the Save.† Through Carniola, the great highway by which so many of the invaders of Italy have passed, the Umbrians, a people whose language is intimately related to the Celtic, may have reached the plains of Northern Italy.

Some of the oldest and deepest morphological changes in Aryan speech are those which affect the Celto-Italic languages. Such are the formation of a new passive, a new future, and a new perfect. Hence it is believed that the Celto-Italic languages may have separated from the rest, while the other Aryan languages remained united. The Celto-Italic union is less apparent than the Indo-Iranian or the Slavo-Lettic, because it dates from an earlier period.

The relations of Celtic with Teutonic are less profound than those with Latin. They affect the culture words rather than the morphological structure, and point to late political supremacy and geographical contact rather than to primitive organic unity.

The relations of the Teutonic family to the Slavo-Lettic are more deep and continuous, as they affect, not only the culture words, but the grammar. The final separation of the Slaves and Teutons must have been comparatively late. The Slavic and Teutonic languages agree largely in metallurgic terms, but differ in the words relating to weapons, agriculture, and navigation. An intimate connection between Slavo-Lettic and Teutonic is also indicated by the fact that they agree in changing a primitive *bh* to *m* in certain case-endings—a change which is not found in the other Aryan languages. On the other hand,

* Bacmeister, *Allemannischen Wanderungen* (Stuttgart, 1867).

† The theory that the Celts extended themselves at a comparatively recent period from Gaul down the valley of the Danube is now very generally abandoned.

a connection between Indo-Iranian and Slavo-Lettic is shown by the fact that in some sixteen words they agree in changing a primitive *k* to *s*—a change which has not occurred in Teutonic. The Iranian name, *bhaga*, for the supreme deity, is also common to the Slaves and Phrygians, but is not found in either Greek or Latin. Hence the Slavo-Lettic family forms a link between the Iranian and the Teutonic, while the relations of Greek are with Indo-Iranian on the one hand and with Italic on the other.

It is now generally admitted that the European languages are not less archaic than the Asiatic, due allowance being made for the fact that the literary monuments of Sanskrit reach back to an earlier time than those of the European tongues. Zend, as we have it, may date from the sixth century, B.C., and Sanskrit from the tenth. But modern Persian preserves less of the primitive Aryan grammar than any other Aryan language except English. It has got rid of declension altogether, and though it has preserved some of the personal suffixes of the verb, it has lost the old tenses. The neo-Hindu languages, which arose out of the Prakrits, or vernacular dialects, about the tenth century A.D., have lost most of the archaic features which distinguish Sanskrit. The neuter gender has disappeared, a new plural and new case-endings have been substituted for the old forms, and the inflexions of tense have been replaced by new forms derived from the participles. It cannot be doubted that this destruction of old forms has been accelerated, if not altogether caused, by the acquirement of Aryan speech in India by non-Aryan tribes.

Among the Lithuanians the opposite has been the case. The language has not extended itself, and those who now speak Lithuanian are probably the direct descendants of those who spoke it two or possibly three thousand years ago. Hence there has been less destruction of grammatical forms than in any other existing Aryan language. Alone among existing languages it has preserved the dual and the old declension. Its phonetic system is inferior only to Sanskrit, and is in some respects even more archaic, despite the fact that the Sanskrit literature is older by nearly 3,000 years than the Lithuanic, which dates only from the beginning of the eighteenth century.

On the whole the Latin, Celtic, and Lithuanian have kept most closely to the primitive system of consonants. The Slavonic and Indo-Iranian languages have developed numerous sibilants and fricatives. The primitive Aryan speech had only one sibilant and two nasals, but the Sanskrit has four sibilants and five nasals. The cerebrals or linguals which are peculiar to the Indian languages are believed to be due to early Dravidian influences. It was formerly thought that the primitive Aryan had only one sound for *r* or *l*, but it is now believed that there were two, the European languages in this respect being more primitive than the Asiatic. In like manner, it was formerly considered that the Indian vowel system was more primitive than the European, but the opposite opinion now finds favor with scholars. Greek has preserved the old tenses better than Latin, and retained the dual. Sanskrit has normally replaced by the genitive the old ablative, which is seen in the Latin *senatu-d* and the Oscan *fructu-d*, and which has disappeared from all the other Aryan languages except Zend. Latin, however, has formed three new tenses—the future in *-bo*, the imperfect in *-bam*, and the perfect in *-vi*, which we have in *amabo*, *amabam*, and *amavi*. The Italic languages, like the Celtic and the Lithuanian, have also created a new middle voice, which afterwards became a passive.

In the retention of the old intransitive voice, of the dual, and of ancient tenses and declensions, Greek is more archaic than Latin. The Doric and Æolic dialects are more archaic than classic Greek, doubtless because the Ionian Greeks were less purely Aryan by race. The loss of the digamma and the tendency to Zetacism among the Ionians may be due to an admixture with the pre-Aryan population from which the Dorians were free. Latin, however, was more faithful than Greek to the primitive consonantal system. Thus Latin has kept the primitive guttural, which Greek often changes to *p* or *t*. Thus, while Latin has *quis* and *quinque*, Greek has τίς and πέντε or πέμπε. Again, Latin keeps the initial sibilant, which in Greek lapses into an aspirate. Thus, Latin has *sex*, *septem*, and *socer*, while Greek has ἕξ, ἑπτά, and ἑκυρός.

We find the same change of *qv* to *p* in Welsh and Gaulish, but not in Irish or Latin. Thus, the Latin *quatuor* is *cethir* in Irish, and *pedwar* in Welsh. The change also occurs in Oscan and Umbrian, as in *pan* for *quam* and *pis* for *quis*. Latin also preserves the old semi-vowel *y* (represented by *j*), which Greek changes into *h* or *z*. Thus we find *jecur* and *jugum* instead of ἧπαρ and ζυγόν.

Hence, in spite of the greater antiquity of the Sanskrit literature, it would appear that some of the European languages in their morphological structure, and still more in their phonetic system, are as archaic as the Asiatic.

On the whole, the Lettic languages have changed the least, and the Teutonic the most. In almost every respect the languages of the brachycephalic people of Central Europe—Lithuanian, Slavonic, Celtic, Umbrian, Latin, and Doric Greek—have adhered more closely to the primitive type than Teutonic, the language of the dolichocephalic people of the Baltic coast. Thus it would seem that the Lithuanians have the best claim to represent the primitive Aryan race, as their language exhibits fewer of those phonetic changes, and of those grammatical losses which are consequent on the acquirement of a foreign speech.

2.—*Dialect and Language.*

The origin of the Aryan languages is veiled in the remote past, and the causes which gave rise to their divergences must be to a great extent a matter for conjecture. But the unknown can often be explained by the known, and the genesis of modern dialects throws considerable light on the obscure genesis of ancient languages.

The method which Darwin has used to explain the origin of species may be applied to explain the origin of languages. Darwin began by showing the origin of varieties—a process which is now in progress in the case of pigeons, dogs, and rabbits. He then argued that species may have arisen out of varieties, and genera out of species. Species became distinct owing to the survival of the fittest, and the extinction of intermediate varieties in the struggle for existence. The families of Aryan speech are analogous to genera, the individual languages to species, and dialects to varieties. Of the origin of languages, as well as of the origin of species, we have no direct knowledge, while the origin of dialects, like the origin of varieties, is less obscure. Hence the study of the origin of dialects can hardly fail to throw light on the origin of languages.

The causes which have led to the formation of dialects can be well studied in the case of Germany. The dialects of German have already become so diverse that a Swiss is unintelligible to a Holsteiner or a Frisian to a Transylvanian ; yet they all speak German. All these dialects are connected by a series of intermediate links—Swabian, Bavarian, Austrian, Hessian, Franconian—affording a continuous passage from one extreme to the other. If these had been extinguished, we should call the speech of Uri, Holstein, and Transylvania separate languages ; as it is, we call them dialects of German. No German dialect is altogether isolated. Each agrees in some respects with one or more of its immediate neighbors, and differs in other respects. The Franconian or central dialects, for instance, share certain phonetic peculiarities with the Low German dialects to the north of them, and others with the High German dialects on the south. The East Franconian differs from the Allemannic more than it does from the Bavarian.

A probable cause can be assigned for some of these dialectic variations. We know that within the historic period German has extended its domain over large districts which are not Teutonic by blood. By race the north-west region of German speech is largely Teutonic, the eastern Lithuanian and Slavonic, the Central region is Celtic, and the Southern is Ligurian. When, toward the close of the second century of our era, the Goths, the Burgundians, and other Teutonic tribes began to move southward to the Danube, and thence into Italy, Gaul, and Spain, the Slaves pressed forward from the East into the lands which had been left vacant, and took possession of the valleys of the Vistula, the Oder, the Elbe, the Saale, the upper Main, and the middle and lower Danube. In the sixth century, as the local names clearly testify, Oldenburg, Mecklenburg, Saxony, Lauenburg, Pomerania, Silesia, the south-eastern part of Hanover, and the Altmark were peopled by Slaves. Slavonic dialects were spoken at Kiel, Lubeck, Magdeburg, Halle, Berlin, Leipzig, Dresden, Salzburg, and Vienna.

During the last thousand years German speech has been slowly winning back its lost provinces, but without displacement of population. The Slavic tribes have not been expelled, but only Teutonized, and the brachycephalic Slavic type remains.

In like manner Eastern Prussia, which is Lithuanian by blood, was Germanized by the Teutonic Knights. The Celtic lands of central Bavaria, the land of the Boii, as well as Würtemberg, Baden, and Hesse, were Germanized in the fourth century by Alemannic, Suevic, and Frankish tribes. In several Swiss cantons the blood is Rhætian, but the speech Burgundian. It is therefore no matter for surprise that in all these regions the Low German speech of the conquerors was modified when it was acquired by the native tribes. The primitive Low German dialects are only spoken in those Frisian and Dutch districts which are Teutonic in blood as well as speech.

We may now go a step further, and examine the case of the neo-Latin dialects which have now become languages. French, Spanish, and Italian are called languages, but they arose out of dialects ; and if the connecting dialects be taken into account, the sharp line of separation which divides the literary languages disappears in the case of the vernacular speech.

Beginning at the North, and excluding the literary languages, we find a series of mutually intelligible dialects of the Langue d'oïl, such as Walloon, Picard, Norman, Burgundian, and Savoyard, which shade off gradually into the dialects of the Langue d'oc, such as Limousin, Auvergnat, Gascon, and Provençal ; and these again into Catalan, Navarrais, Castilian, and Andalusian, while Savoyard forms the transition to Piedmontese, through which we successively arrive at Lombard, Venetian, Tuscan, Corsican, Neapolitan, Calabrese, Sicilian, and Maltese, Sardinian forming a link between Spanish and Italian.

Owing mainly to political causes, the Tuscan, Castilian, and Parisian dialects have become literary languages, and with the spread of education are rapidly extinguishing the provincial vernaculars. If it had so happened that all the intermediate dialects between Walloon and Sicilian had been extinguished, the speech of France and Italy would be almost as different as Sanskrit and Zend. In the case of the Aryan languages there has been an extensive extinction of intermediate dialects. Instead of an inclined plane of speech, such as that which extends from Uri to Holstein, or from Picardy to Calabria, we have, as it were, a staircase, the inclined plane has been broken up into irregular and disconnected steps.

The process by which the primitive Aryan speech first became extended over a vast region, and then broke up into dialects which became the parents of the Aryan languages, must be analogous to the process by which in historic times the Latin language, the dialect of one city, Rome, spread over the whole Roman empire, and then broke up into the neo-Latin languages. The neo-Latin languages arose out of the local vernacular dialects, which existed side by side with the literary Latin. These dialects owe their origin to the fact that the Latin of the legionaries was acquired by the conquered races, whose languages were extinguished, but left their mark on the acquired speech.

Thus the Latin speech when acquired by Ligurians gave rise to the Langue d'oc, by Gauls to the Langue d'oui, by "Celts" to Castilian. by Iberians to Portuguese, by Celtiberians to Aragonese. In the Alps there are three Ladino dialects which may owe their peculiarities to the influence of the old Rhætian language on the acquired Latin speech. Roumanian has doubtless been infected by the speech of the ancient Dacians, among whom the Roman colonists lived. In several cases the vowels have acquired a nasal sound, or have been converted into diphthongs. The article has become a suffix; we have, for instance, *omu-l* (*homo ille*), the man. The fact that this peculiarity is found also in Bulgarian, a Slavonic language, and also in Albanian, makes it probable that this usage may have been derived from the old Illyrian family of speech to which Dacian probably belonged.

Italian is nearer to Latin than Provençal and Provençal than French, because there was a smaller foreign element in Italy than in Southern Gaul, and in the south of Gaul than in the north. The change of speech is phonetic rather than lexical, and largely due to the foreign accent with which Latin was spoken by those to whom it was an acquired language.

The dialect of the Isle de France has become the literary language of France, owing to the accident that the Capets came to fix their capital at Paris. Umbrian, Oscan, and Messapian gave place to Latin because the Roman republic subdued the rest of Italy. Because Athens was the intellectual centre of the Hellenic world, because Castilian was spoken at Madrid, because Mohammed was born at Mecca, the local dialects of Attica, Castile, and Mecca have become the literary languages which we call Greek, Spanish, and Arabic.

When a literary language has been established, local dialects tend to disappear. Owing probably to political causes, the dialects which must once have bridged over the gulf between Slavonic and Iranian. Armenian and Greek, Latin and Celtic, have been extinguished. It is thus that we must explain the growth of local dialects into languages, and the extinction of intermediate varieties.

It has often happened that the dialect which has succeeded in the struggle for existence has been one which has incorporated the most numerous foreign elements. Latin was by no means the purest of the Italic dialects. Attic Greek was further from the primitive Hellenic speech than Doric or Æolic. Literary English is the mixed language of the Danelagh rather than the pure Saxon speech of Wessex or the pure Anglian of Northumbria, and Frisian is nearer to the primitive Teutonic speech than literary German.

3.—*The Lost Aryan Languages.*

The tendency of vernacular dialects to disappear, thus accentuating the distinctions between those which survive, will help to explain the extinction of linguistic families which must formerly have been the missing links between existing languages.

In some cases we are able to form probable conjectures as to the nature of the languages which have been exterminated, and which might have bridged over the gulf between divided families of Aryan speech.

The Armenians are believed to have been an eastern extension of the Phrygians, who themselves have been identified with the Briges of Thrace. Thus, of the few Phrygian words which we possess, *βαγαῖος*, the Phrygian name of the Supreme God, is the Iranian *Bhaga*, and the Slavonic *Bogu*.* Hence we may conjecture that Phrygian and Thracian might supply some of the missing links between Greek, Armenian, Slavonic, and Iranian. Between the last two, Sarmatian and Scythian were probably interposed. There can be little doubt that several Iranian languages have disappeared. The existing Iranian languages —Pushtu, Persian, Kurd, and Baluchi—resemble the patches of Bagshot sand which crown the heights near London—remnants of a once continuous formation now extensively destroyed by denudation.

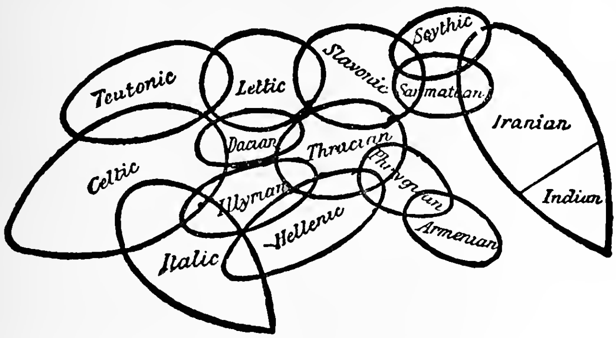
The ancient Dacian, our only knowledge of which is derived from geographical names and a few plant names preserved by Dioscorides, was conterminous, or nearly so, with Celtic, Illyrian, Thracian, and Lithuanian. The Dacian name of the cinquefoil, *propedula*, reminds us of the Celtic *pempedula*. Dacian probably belonged to the Thraco-Illyrian family, and if it had come down to us would doubtless have supplied a valuable link between Celtic, Albanian, Greek, and Lithuanian. Albanian, again, is the descendant of the old Illyrian. Its linguistic position is doubtful. Hehn thinks it approaches most nearly to Greek, Blau believes it was nearer to Iranian ; but, as Greek has closer relations with Indo-Iranian than with any other family, the

* Renan, *Langues Sémitiques*, p. 47.

old Illyrian, if it had been known to us, might have helped to bridge over the existing gulf. Illyrian, however, has left its mark in the region which it once occupied. Albanian, as we have seen,* like Roumanian and Bulgarian, possesses a definite declension, obtained by means of a suffixed article—a peculiarity probably derived from the old Illyrian, which may have been a link between the Italic, Hellenic, and Lettic languages.

Thus it would appear that three links—the Dacian, Illyrian, and Thracian—are wanting between the European languages. The Dacian and the Thracian might have formed the transition between the Slavonic to the East, the Celtic to the West, and the Greek to the South. Phrygian and Thracian might have bridged the gulf between Armenian and Greek ; Sarmatian, between Slavonic and Iranian.

The destruction of so many of the central links may help to explain why the Northern and Southern languages of Europe have so little in common. If the lost languages had survived, the probable connections between the Aryan languages might be represented by the following diagram:—



4.—*The Wave Theory.*

Reason has been shown for believing that the Aryan languages were evolved out of dialects, much in the same way that the Teutonic dialects or the neo-Latin languages have been formed.

The probability that the Aryan languages were evolved, so to speak, *in situ*, has been demonstrated by Schmidt in a tract to which reference has already been made.† Schmidt's "wave theory" has, however, so important a bearing on the question of the region where Aryan speech originated that a few pages must be devoted to setting it forth in greater detail.

Relying on certain words and forms which are confined to the European Aryans, Fick and Schleicher had maintained that there was an early and fundamental separation between the European and Asiatic

* See p. 152, *supra*.

† See p. 21, *supra*.

Aryans; while Grassmann, Pauli, Sonne, and Spiegel contended that Greek was nearer to the Asiatic languages than to Latin or Teutonic; and Bopp and Pott in like manner urged the close phonological resemblances between the Slavonic and the Indo-Iranian languages.

Schmidt showed that all the Aryan languages formed links in a chain, that Slavonic can be severed neither from German on the one side nor from Iranian on the other, while Greek forms the connecting link between Sanskrit and Latin.

Assuming the close connection of Zend and Sanskrit, which is admitted by all scholars, and regarding them as sister languages, Schmidt showed that the three Baltic families—Teutonic, Lettic, and Slavic—are united by 143 verbal links, all three being joined together by 59 links, Teutonic and Slavic by 50, and Teutonic and Lettic by 34. He then showed that the Indo-Iranian, or Eastern group, is united to the Baltic, or Northern group, by 90 links, of which 61 specially connect it with the Slavo-Lettic family, and only 15 with the Teutonic. While the intimate connection of the three Baltic families is evidenced by 143 links, there are nearly as many, 132, which unite the two Mediterranean families—Italic and Hellenic; the Asiatic group being united with the Mediterranean by 123 links, of which 99 connect it with the Hellenic family, only 20 with the Italic, and 4 with both. There are also 10 links uniting the Slavo-Lettic, Indo-Iranian, and Hellenic families.

These links are only in the vocabulary, but there are others in the grammatical structure. Thus Teutonic and Slavo-Lettic agree not only in the words for silver, rye, wheat, beer, and thousand, but in the change of a primitive *bh* to *m* in certain case-endings. Lettic and Teutonic replace *d* by *l* in the numerals e*l*even and twe*l*ve. Slavo-Lettic agrees with Indo-Iranian in the designation of the supreme deity, Bogu, in the word for marriage, and in several numerals; and also in two cases of the noun, four forms of the verb, and certain forms of the pronoun. Greek shares one form of the verb (the *futurum exactum*) with Latin, and three with Indo-Iranian. Iranian, Greek, and Slavonic change *s* into *h* between two vowels, and Iranian and Greek replace an initial *s* by *h*. In many culture words and in several grammatical forms Latin is nearer the Northern languages than it is to Greek. The close agreement of Latin with Celtic has already been pointed out. They have both formed a new passive and three new tenses in the same way. The morphological peculiarities of Lithuanian are shared partly with the European, and partly with the Asiatic languages. Thus, in the word *melzu*, "I milk," the *e* is European, the *z* Asiatic. In *des-ina-mus*, a dative plural feminine, the vowel of the root is distinctively European, the stem suffix is Indo-Iranian, and the case-suffix distinctively Slavo-Teutonic. Hence we see that the great families of Aryan speech, Indo-Iranian, Hellenic, Celto-Italic, Teutonic, and Slavo-Lettic, are indissolubly bound together. Slavo-Lettic can be no more torn from its connection with Teutonic on the one side than from Iranian on the other. Greek is linked with Sanskrit as closely as with Latin.

The way the Aryan languages are interlinked seems to prove that there could have been no successive migrations from Asia.* The European languages could only have arisen in Europe at a time when the Aryan nations occupied much the same relative positions as in the historic period. The Slaves, for instance, must from the first have been between the Iranians and the Germans, and the Greeks between the Latins and the Indo-Iranians. The more remote languages are from each other, geographically, the fewer are the peculiarities which they share in common. Thus, Schmidt has shown that the connection of Indo-Iranian with Slavonic is closer than its connection with Teutonic in the proportion of more than 10 to 3. In like manner, the connection of Indo-Iranian with Greek is closer than its connection with Latin in the proportion of nearly 5 to 1.

Schmidt maintains that the Aryan linguistic area was at one time homogeneous. In various portions of this domain he supposes that tendencies to variation arose, and spread like undulations from the centre of disturbance. Thus in one spot a tendency may have arisen to change the primitive guttural tenuis into a sibilant—a tendency which affected the regions occupied by the forefathers of the Indo-Iranians, the Armenians, and the Letto-Slaves, so that the Greek ἑκατόν, which is *cét* in old Irish, *centum* in Latin, and *hund-* (=*kunt*) in Gothic, corresponds to *çata-m* in Sanskrit, *sate-m* in Iranian, *suto* in old Slavonic, and *szimtas* in Lithuanian.

At some other time and in some other region we may suppose that there was a tendency to change the primitive *bh* in the case-endings *-bhi*, *-bhis*, *-bhya(m)s*, to *m*—a tendency which only extended to the ancestors of the Slaves and Teutons, so that in place of the old Irish *fera-ib* and the Latin *hosti-bus* we get *vulfa-m* in Gothic, and *vluko-mu* in old Slavonic.

At a third point a new passive was formed, which extended to the Celtic and Italic languages, and perhaps more remotely to the Lithuanian, giving us the old Irish *bera-r* and the Latin *fero-r*. In the same way Celtic and Teutonic were possibly affected by a tendency to denote past time by prefixes. Other changes affected the whole European region, and included the Armenian ; others merely the Italo-Hellenic domain.†

In like manner we find certain primitive worships extending over contiguous regions. Bhaga, as the name of the supreme deity, is found among Iranians, Slaves, and Phrygians ; Woden only among Celts and Teutons ; Juno and Vesta are confined to Greeks and

* See the diagram on p. 13, *supra*. † Schmidt, *Verwantschaftsverhältnisse*, p. 17.

Latins; Uranus to Greeks and Indians; Mithra to Indians and Iranians.

These facts are clearly inconsistent with any theory of the migration of the Aryans from Asia to Europe at any time subsequent to the period of linguistic unity. The Aryan languages must have originated when the Aryan nations occupied much the same relative positions which they now hold.

5.—*Language and Race.*

The intimate interlinking of the Aryan languages which Schmidt has established proves that the linguistic separation must have taken place at a time when the Aryan races occupied nearly the same relative positions as at the beginning of the historical period. But Schmidt assigned no cause for the local dialectical disturbances or tendencies to variation which he assumed to have taken place.

This has been done by the anthropologists—more especially by Penka. We have already seen that Aryan languages are spoken by at least four European races, only one of which could have been Aryan by blood. The others must have exchanged their primitive tongue for Aryan speech. The evidence adduced by Penka and Pösche to prove the mutability of speech and the comparative stability of race has also been summarized. We have also seen that the peculiarities which distinguish the neo-Latin languages may be due to the acquirement of Latin speech by Iberians, Gauls, Rhætians, or Dacians. The origin of the dialects of ancient Italy and Greece, and of the modern provincial dialects of France, Spain, Germany, and England, may to some extent be explained in the same way.

We are therefore entitled to extend this principle as a *vera causa*, which may account for the origin of the dialects out of which grew the Aryan families of speech. In other words, we may attribute many, if not all, of the differences which distinguish the Aryan languages to the Aryanization of non-Aryan races.

In some cases the influence of a foreign idiom can be definitely traced. Thus Spiegel has shown the influence of Semitic grammar on Persian, and of Dravidian grammar on Sanskrit. It is the same with Sanskrit phonology; the linguals and cerebo-dentals, which are so characteristic of Sanskrit, belonged to the tongue of the subjugated Dravidians, and have infected Aryan speech in India, but in no other land.

It is not impossible that some of these phonetic changes may be due to causes purely organic. Duncan Gibb has proved that in extreme types, such as the negro and the European, there are actual differences in the structure of the larynx, which may suffice to explain why negroes find it so difficult to utter certain sounds which come easily to ourselves. A negro finds it almost impossible to pronounce the English *th*, which he transforms into *d*, while a Swiss turns it regularly into *z*. A Russian, on the other hand, turns it into *f*, the name Theodore, for instance, becoming Feodor. We have a similar change in Latin, *fumus* answering to θυμός, and *rufus* to ἐρυθρός.

There are many such phonetic tests of race. On the night of the Sicilian vespers, the French fugitives, with the sword at their throats, were bidden to say the word *ciciri*, and if the *c* was pronounced as *s*, and not like our *ch*—if they said *sisiri* instead of *chichiri*—they were recognized as Frenchmen, and killed.

Again, when the Mamelukes in Egypt exterminated the Arabs of the Said, they made them say the word *dakik* (flour), in order to ascertain whether the guttural was pronounced as a *k* or a *g*.

The men of Gilead said *shibboleth*, but the men of Ephraim "could not frame to pronounce it right, and said Sibboleth," and were slain at the fords of Jordan (Judges, vii., 6).

The Polynesians are unable to say "Mary," which they change to *Mali*. The Chinese have turned Benares into *Po-lo-nai*, Brahma into *Fan*, and Christ into *Ki-li-sse-tu*. The Caffres of the Cape pronounce the word "gold" as *igolide*, and "sugar" as *isugile*, while they are able to catch some of the difficult Hottentot clicks which an Englishman finds impossible, even after long practice—*experto crede*. These are extreme cases; but we may take it as an axiom that, whenever a new language is acquired by foreigners or by subject races, there will be certain classes of sounds which will be pronounced with difficulty, and will therefore, as a rule, be evaded or be inaccurately reproduced. This is especially the case with the soft and aspirated mutes. Thus, when Aristophanes brings barbarians on the stage, he makes them replace the difficult sounds of the Greek aspirated tenues, φ, θ, χ, by the simple tenues π, τ, κ. The same difficulty was felt by the Goths. Ulphilas represents the Greek χ by *k*. The Ugrians find the soft mutes *b*, *g*, *d* difficult to pronounce, and change them to *p*, *k*, *t*. Thus a Magyar speaking German says *pinter* instead of *binder*, *pek* instead of *beck*, and *pleh* instead of *blech*. Shakespeare's foreigners do the same. Fluellen in "Henry V.," and Sir John Evans, the Welsh parson in the "Merry Wives of Windsor," substitute *p* for *b*, *t* for *d*, and *f* for *v*, and introduce peculiar idioms and a simplified form of English grammar. "Pragging knave, Pistol, which you and yourself and all the world know to be no petter than a fellow, look you now, of no merits: he is come to me, and prings me pread and sault yesterday; look you, and bid me eat my leek." "It is that ferry person for all the 'orld." "The tevil and his tam." Dr. Caius, the Frenchman, is unable to pronounce our *th* and *w*. Mrs. Stowe's negroes, Mr. Black's

Highlanders, and Lever's Irishmen encounter similar difficulties, phonetic and grammatical, when they speak English. The pidgin-English of a Chinaman differs from that of a Malay or a Chinook.

It may therefore be regarded as probable that racial tendencies may explain, to some extent, the differentiation of the Aryan languages. This hypothesis derives support from the existence of similar phonetic tendencies in French and Welsh. Two Aryan languages, Latin and old Celtic, have been modified in similar ways. The French, like the Welsh, find a difficulty in pronouncing the initial double consonants *sc*, *sm*, *sp*, *st;* and in both cases the difficulty is overcome in the same way, by prefixing a vowel. The Welsh have made the Latin *schola* into *yscol*, *spiritus* into *yspryd*, and *scutum* into *ysgwyd*. Similarly the Latin *schola* became *escole* in old French, and *école* in modern French ; *spiritus* became *esprit; sperare* became *espérer; species* became *espèce* and *épice; spada* became *espée* and then *épée; scabellum* became *escabeau; scala* became *eschelle* and then *échelle*.* We find other regular phonetic changes, such as *n* for *m*, *r* for *l*, and *ch* for *c*, as in *rien* from *rem*, *sente* from *semita*, *orme* from *ulmus*, *chef* from *caput*.

In some of these words we see another characteristic common to French and Welsh. This is the Celtic tendency to the mutilation of unaccented syllables. The accented syllable is preserved, the short atonic syllables are suppressed. Thus the Latin words *pórticus ásinus. septimána*, *liberáre*, and *régula* have become in modern French *porche*, *âne*, *semaine*, *livrer*, and *regle*, and *semetipsissimum* has become *même*, In like manner the Latin *benedíctio*, *papílio*, and *córpus* became *benditt*, *pabell*, *corff* in Welsh, and *Caerlon* represents *Castra Legionum*.

In French as well as in Welsh this tendency to contraction has played havoc with the declensions. In Welsh there are hardly any remains of the old suffixes which indicated case, and prepositions have to be used instead. French has in like manner lost its cases, which have been replaced by the same device as in Welsh, and we have to say *à la femme*, *de la femme*, *pour la femme*. Similar ethnic tendencies produce similar results on language. If we were ignorant of the history of the French language we might probably be led to connect it too closely with Welsh, owing to the superficial resemblance due to these common tendencies.

In certain words the aspirated tenues in Greek, Sanskrit, and German answer in Latin, Celtic, and Lithuanian to the corresponding unaspirated tenues, and it is found that the Slaves and Roumanians, who also belong to the brachycephalic race, make the same change when they speak German. In South Germany and Switzerland, which were originally Celtic, and where the Celtic skull-type has reasserted itself, we find that the North German *kh*, *th*, and *ph* are frequently changed to *k*, *t*, and *p*.

* See Max Müller, *Lectures*, vol. ii., pp. 195, 196.

During the historic period Aryan speech has been extending itself over Finnic territory. Scattered over the valley of the Volga, the linguistic map of Russia* shows sporadic settlements of Finns—Mordwins, Wotiaks, and Tscheremiss—who are gradually acquiring Slavonic speech. Moscow in the tenth century lay in Finnic territory; it is now the heart of Russia. In the seventh century the whole valley of the Dvina was Finnic; it is now almost wholly Slave. Over one-half of Russia the blood is probably Finnic, and we may therefore expect to find peculiarities of Ugro-Finnic phonology in Russia. Now Anderson has collected a number of instances of the tendency in the Finno-Ugric languages to change a guttural into a sibilant.† It is worthy of note that this change is found also in the Slavo-Lettic languages, which are spoken by races which come nearer than any other Aryans to the physical type of the Ugro-Finns. The same sibilation of gutturals is found also among the Indo-Iranians. This may be explained by the hypothesis of Penka that the Indo-Iranians were originally Aryanized Ugrians. But while the Indo-Iranian languages share in common this peculiarity of the Finno-Ugric phonology, the Iranian languages, which are so closely related to the Indian, are entirely free from the characteristic Dravidian sounds, the cerebrals, and linguo-dentals, which are found in no Aryan language except Sanskrit. These peculiarities in the phonology of Sanskrit are indications of its migration from Finno-Ugric to Dravidian territory.

Anderson has also collected instances of the Ugric fondness for inserting a parasitic *j* or *v* after explosives,‡ owing to which *k* becomes *č*, *t*, or *t'*. We may detect similar tendencies among the brachycephalic Aryans, which may explain the equivalence of *kis*, *quis*, *tis*, and *pis*; of *keturi*, *quatuor* and *petuar*, and of *pankan*, *quinque*, and *pimp*.

From the foregoing instances it may be concluded that when the language of conquerors is acquired by subject races the more difficult sounds will be more or less modified. In such a case there will also be a difficulty in learning the more elaborate grammatical inflexions, which are not easy to catch and remember. A destruction of grammatical forms will ensue, new formations will be developed, and the simplified grammar will ultimately be adopted by the conquerors in their intercourse with their more numerous subjects.

Of this process we have actual instances. Mr. Kington Oliphant has shown the result of the Danish conquest in breaking up the old Anglian inflexions. He has shown how, except in the case of a few plurals like *oxen*, the genitive and plural in *es* swallowed up the old

* See the map in the *Suomalais-Ugrilaisen Seuran Aikakauskirja*, part i. (Helsingfors, 1886.)

† Anderson, *Studien*, p. 184.

‡ *Ibid.*, p. 185.

genitives and plurals in *an*, and uncoupled the preposition from the verb.* The grammar was simplified and made more easy to acquire. Mr. Oliphant has also shown the influence of the Norman Conquest in causing certain French prefixes and suffixes to be tacked on to the English stems. †

The Teutonic conquest of Gaul had a similar result. As early as the fifth century four of the six cases of the noun were lost, and replaced by prepositions. A new future was found from *habeo*. Instead of *amabo* we find *j'aimer-ai*, equivalent to *ego amare habeo*, the pronoun being prefixed to make the new formation intelligible; and then, when this had become familiar, a more emphatic form, *je vais aimer*, was invented.‡ But even *amabo* was not the old Aryan future. In Umbrian, Oscan, and Celtic the old future in *s* was altogether lost, and there are only faint traces of it in Latin. § The new future in *bo* was formed from the auxiliary verb *fuo;* so that *ama-bo* is "I am to love."

In the Slavo-Lettic languages the old perfect has disappeared without a trace, and it is nearly lost in the old Irish.‖ In Bulgarian, a Slavonic language acquired by a Turkic tribe from the conquered Slaves, very few of the old grammatical forms have been retained, while the Servians and Croats, who are more purely Slave in blood, have kept the old aorists and imperfects. But even the Old Church Slavonic, which has kept the aorist and the present, has lost the primitive imperfect and the reduplicated perfect. It has acquired three new sibilants and two nasals, it prefixes a euphonic *y* to words beginning with a vowel, it has lost the final consonants, and has changed the primitive diphthongs into simple vowels. In like manner Bulgarian, Roumanian, and Albanian have acquired, probably from the old Illyrian or Dacian, a suffixed article.

The Celts, when they invaded Britain, found the country in possession of the Silurian race, whose descendants can be traced in Denbighshire and Kerry. Professor Rhys believes that he has detected the influence of this race on the Celtic tongues. He thinks that the incorporation of the pronouns between the Irish verb and its prefixes and the inflexion of the Welsh prepositions, as *erof* "for me," *erot* "for thee," *erddo* "for him," is due to the influence on Celtic speech of a pre-Aryan population.¶

Hence it seems probable that many of the phonetic and grammatical distinctions which differentiate the Aryan languages are due to the fact, with which the researches of the anthropologists have already made us familiar, that the Aryan-speaking nations belong, not to one race, but to several, who have in remote times abandoned their primitive speech for that of Aryan conquerors.

* Oliphant, *Standard English*, pp. 47-52.
† *Ibid.*, pp. 241, 247.
‡ Sayce, *Principles*, p. 29.
§ Schleicher, *Compendium*, pp. 821, 822.
‖ *Ibid.*, p. 746.
¶ Penka, *Origines Ariacæ*, p. 212.

6.—*The Genesis of Aryan Speech.*

Many years ago Professor Max Müller affirmed his belief that, "in the grammar of the Aryan and Semitic languages, we can discover the stamp of one powerful mind, once impressed on the floating materials of speech, at the very beginning of their growth, and never to be obliterated again in the course of centuries."*

The doctrine of evolution, which has so profoundly affected the physical sciences, has now been applied to the science of language; and it is more in accordance with modern scientific principles to suppose that language has been slowly developed during the lapse of innumerable ages, and that the Aryan inflexions, instead of being invented by "one powerful mind," were unconsciously evolved out of some ruder form of speech.

What this form was can only be matter for conjecture, but we may legitimately examine the non-Aryan languages with the object of discovering which of them approaches most closely to the primitive Aryan, and whether any probable hypothesis can be formed as to the nature of the mother-speech from which the Aryan languages were evolved.

The Aryan territory is circumscribed by three other linguistic families—the Hamitic, the Semitic, and the Ural-Altaic. Among these its nearest congener must be sought, all other families of speech being too remote, both geographically and structurally.

The Iberians, as we have seen, were probably non-Aryan by race and language. Their physical type was that of the North African tribes, who spoke Numidian dialects belonging to the Hamitic family, and remotely akin to the old Egyptian.

Many philologists of repute are of opinion that the inflexional Semitic languages were evolved out of some tongue of the Hamitic class,† and they have pointed out striking grammatical agreements between the Semitic and the old Egyptian.

But all attempts to connect Aryan and Semitic speech have conspicuously failed. Both, it is true, are inflexional; but the inflexion is of a wholly different character. The verbal roots are also different, the formative elements are different, and are employed in a different manner. There is an impassable abyss between the Semitic and Aryan languages. It is impossible to conceive that the one could have been evolved out of the other.

There are no white races except the Ural-Altaic and the Semitic from which the white Aryan race could have originated. In physical character the Mediterranean dolichocephalic Aryan-speaking race

* Max Müller, *Survey of Languages*, p. 86.

† F. Müller, *Allgemeine Ethnographie*, pp. 32, 527; Sayce, *Introduction to the Science of Language*, vol. ii., p. 178; Hovelacque, *Science of Language*, pp. 152, 174.

resembles the Semites; while the Central European brachycephalic race agrees with the Finno-Ugric type. But there is no such impassable gulf between Ural-Altaic and Aryan speech as there is between Aryan and Semitic.

The Semitic languages have prefixes and infixes, whereas the Aryan and Ugro-Finnic languages possess only suffixes. Hence there is an agreement in their fundamental structure. It is true that the Ugro-Finnic languages are agglutinative; but in some of them, as in the West Finnic class, the agglutination has almost reached the inflexional stage, differing little from the primitive stage of flexion which we discover in the more archaic Aryan languages. There is no absolute line to be drawn between agglutination and inflexion. Isolating languages tend to become agglutinative, agglutinative languages to become inflexional; inflexional languages tend ultimately to lose their flexions, and become analytic. Chinese is monosyllabic; Tibetan shows a tendency to agglutination. The Ural-Altaic languages are in the agglutinating stage; but Finnic, the most advanced of this class, has almost reached the stage of inflexion. Aryan languages are inflexional; but in Persian, French, and English the inflexions have almost disappeared, and the analytic stage has been nearly reached.

The farther we go back into the history of Aryan speech the more agglutinative and less inflexional is the character of the grammar The more archaic Aryan languages, such as the Lithuanian, approach the most closely to the transparent Ugro-Finnic grammar, which is simple and logical; while in other Aryan languages the grammatical forms are degraded and obscure. On the other hand, the more developed Finnic languages have become less agglutinative and more inflexional. Professor Max Müller admits that in the Finnic grammar we find a closer approximation to the Aryan than can be elsewhere discovered. He goes so far as to say that " we might almost doubt whether the grammar of this language [Finnic] had not left the agglutinative stage and entered into the current of inflexion with Greek and Sanskrit."* Dr. Schrader admits that it cannot be denied that the Aryan languages exhibit traces which show that they have emerged from a lower stage of development, nearer to that of the Ural-Altaic languages.

The Finnic, which is the most advanced of the Ural-Altaic languages, also approaches the Aryan languages in requiring the adjective to agree with the substantive in number and case. Moreover, in the Finnic and Aryan languages the ultimate verbal roots are largely the same in sound and meaning; the pronominal and other formative elements are largely the same, and are used in the same way, and with the same import.

There has been a constant tendency to assimilate the forms of the

* Max Müller, *Lectures*, vol. i., p. 319.

Aryan cases and to obliterate the distinction of the grammatical forms, while the recuperative power of producing new forms seems to be now lost. At the same time, while cases and tenses have disappeared, there has been a tendency to multiply declensions and conjugations. But primitive Aryan speech possessed only two forms of declension and conjugation—those belonging to the vocalic and consonantal stems—and these probably are ultimately reducible to one. In this it agreed with the primitive Ural-Altaic speech, which primarily possessed only one form of declension and one of conjugation.

The Altaic languages still possess the power of developing cases with great readiness—a power which Aryan speech must have once possessed, but has now lost. The primitive Aryan speech was rich in cases, which were formed by agglutinated postpositions. Latin kept five, the mediæval Langue d'oïl kept two; modern French has lost them all. As these cases fell into disuse it became necessary to supply the defect by prepositions. In the proto-Aryan speech there were certainly seven and probably nine cases—a genitive, a dative, and an accusative, two locatives, two instrumentals, and two ablatives. With them we may compare the nine cases in Yakut and the fourteen in Finnic, which possesses illative, prosecutive, and mutative cases. We have seen that some Aryan languages, such as Sanskrit and South Slavonic, have developed numerous consonants which the primitive speech did not possess. The Ugro-Altaic phonetic system seems to be a simple stage out of which the Aryan system might have been evolved. It possesses only one guttural, *k*, while the Aryan has six; one dental, *t*, while the Aryan has three; and one labial, *p*, while the Aryan has three.

It is, however, alleged that there are three radical distinctions which separate the Aryan and Finnic languages. They are gender, the formation of the plural, and the law of vocalic harmony.

The vocalic harmony, which is such a characteristic feature of the Ural-Altaic languages, has been adduced as the most fundamental difference by which they are distinguished from Aryan languages. But some of them, as the Tscheremiss and the Wotiak, possess only faint traces of it. M. Adam supposes that they have lost it. If so, the Aryan languages might have lost it also. M. Hovelacque, on the other hand, believes that the vocalic harmony is of comparatively recent origin, and that the Tscheremiss and Wotiak have only imperfectly acquired it.

The next great difference is in the formation of the plural. The Aryan and Ural-Altaic languages have three numbers—singular, dual, and plural. In this they agree, but we have to face the formidable difficulty that, though the dual is formed in the same way, the structure of the plural is altogether different. In the Finnic languages the sign of the plural is inserted between the stem and the pronominal or postpositional suffixes, whereas in Aryan languages the sign of the plural comes last. But this difference, fundamental as it may seem, may rather be regarded as a sign of primitive unity. Professor Sayce has shown reasons for believing that in the primitive Aryan speech there was no plural, but only the singular and the dual. "Nothing," he says, "seems to us more natural, nay, more necessary, than the existence of the plural; we might suppose that its roots go deep down into the very beginnings of language, and yet there are two facts which militate most clearly and decisively against such an opinion."* One is the occasional survival of the dual, which would have been needless if the plural had been in existence, as we see by the fact that the existence of the plural has caused the dual to be dropped. "The dual," he says elsewhere, "was older than the plural, and, after the development of the latter, survived only as a useless encumbrance, which most of the Aryan languages contrived to get rid of."† The same was the case in the Finnic languages, which originally had a dual, as is proved by its survival in Ostiak, Lapp, and Samoyed, while in the more cultured languages it has disappeared. The second fact is that many families of speech possess a dual, but have not yet developed a plural. The Accadian and Basque possess the plural only in an imperfect and rudimentary form. That the plural was a late formation in the Ural-Altaic languages is proved by the fact that they have not all adopted the same plural suffix. It is *t* in Finnic, *k* in Magyar, *lar* in Turkic, and *nar* in Mongolic.‡ The Aryan and Finnic languages form the dual in the same way. In both the dual suffix follows the case-ending or the pronominal suffix. The dual suffix is also believed to be identical in its origin, having been constructed out of the same pronominal elements in Samoyed, Lapp, and Ostiak, as in those Aryan languages which have retained the dual.

But while the formation of the dual is the same in the Aryan and Finnic languages, that of the plural is different. In the Aryan languages it was formed on the model of the dual, the plural suffix simply taking the place of the dual suffix. In the Finnic languages it is formed by a plural suffix, *t*, inserted before the pronominal or postpositional suffixes, just as in English we tack on the sign of the genitive in such words as *man* and *men*, and say "the man's boots" or "the men's boots"—a formation which corresponds to that in the Finnic languages; whereas in primitive Aryan speech the sign of case comes first, as in the word *nobis*, where *bi* is the sign of the case, and *s* of the plural. In a Finnic language the order of these suffixes would be reversed.

Hence from the agreement in the formation of the dual, and the

* Sayce, *Principles*, p. 258.

† Sayce, Article "Grammar" in the *Encyclopædia Britannica*.

‡ Kellgren, *Die Grundzüge der Finnischen Sprachen*, p. 59.

disagreement in that of the plural, we see that Aryan speech might have been evolved out of a language of the Finnic class at a time when both were still in the stage which Professor Sayce assigns to the primitive Aryan speech; that is, when, like the Hamitic languages, they possessed only the singular and the dual.

The third difference between Aryan and Finnic languages which has been thought fundamental is that the Finnic languages, like the rest of the Ural-Altaic class, are destitute of gender. Dr. Schrader considers that the absence of gender is the point in which the Ural-Altaic languages are most decisively distinguished from both the Aryan and Semitic. But here again Professor Sayce maintains the probability that the primitive Aryan speech agreed with Finnic in the absence of gender. He considers gender a later formation—"the product partly of analogy, and partly of phonetic decay." "There are many indications," he continues, "that the parent Aryan, at an early stage of its existence, had no gender at all." The terminations of father and mother, *pater* and *mater*, for example, are exactly the same." Feminines like *humus*, or masculines like *advena*, "show that there was a time when these stems indicated no particular gender, but owed their subsequent adaption, the one to mark the masculine, and the other to mark the feminine, to the influence of analogy." *

We therefore conclude that the language out of which Aryan speech was evolved must have agreed with the Ural-Altaic in being destitute of gender.

It appears, therefore, that none of the differences which have been adduced as fundamental distinctions between the Aryan and Ural-Altaic languages are really primitive. Aryan inflection arose out of agglutination, and it must at one time have been more simple and more regular; the Aryan cases must originally have been more numerous; the genders and the plural are new formations; and in the Ural-Altaic languages the vocalic harmony cannot be regarded as an essential law. Thus while the differences which distinguish the Aryan and the Semitic languages go down to the very foundations of speech, those which divide the Aryan from the Ural-Altaic languages are not radical. They are all neologisms—new formations, which, in the course of many millenniums, might be expected to arise.

On the other hand, there are points of structural agreement which can only be explained as due to a primitive unity. These have been set forth by Diefenbach, Cuno, Anderson, and above all by Weske†;

* Sayce, Article "Grammar" in the *Encyclopædia Britannica*.

† Diefenbach, *Origines Europææ* (Frankfort, 1861); Cuno, *Forschungen im Gebiete der Alten Völkerkunde* (Berlin, 1871); Anderson, *Studien zur Vergleichung der Indo-Germanischen und Finnish-Ugrischen Sprachen* (Dorpat, 1879); Weske, *Ueber die historische Entwickelung der Finnischen Sprachen im Vergleich mit der Indo-Germanischen* (Dorpat, 1875).

and the conclusions of these scholars must now be briefly set before the reader.

The agreements in the vocabulary are numerous, but as a rule are not primitive. They are largely, as has been shown by Thomsen, Ahlqvist, and Schrader,* culture words borrowed from the Swedish, Slavonic, and Iranian languages.

But when we penetrate deeper, and come to the verbal roots out of which the vocabulary has been framed, we find, as Anderson and Cuno have shown, that the roots are to a large extent identical, and that these verbal roots have been built up into word-stems by the same processes, and by aid of identical formatives. To take an example, we have both in Aryan and Finnic the verbal root *kar*, to run, to move. From this we get in Finnic the word *ker-ap*, a carriage, and in English the word *char-iot.* Here, from the same root, words of similar meaning have been independently constructed.

These identical verbal roots are numerous. To give a few instances, we have both in Aryan and Finnic languages the verbal roots *kad*, to fall; *kak*, to bend, with the secondary meaning to excrete; *kap*, to hold; *kam*, to bend; *kar*, to work, to do, with the secondary meaning to work evil or injure; *kas*, to praise; *kal*, to be cold; *ku*, to swell out; not to speak of certain resemblances in the roots of the numerals, which have been set forth by Cuno.†

In the next place, both in Aryan and Finnic, identical formative suffixes are attached to the verbal roots to form stems. Thus the formative *ma* is employed in the same way both in Aryan and Finnic for the construction of verbal nouns.‡ In Finnic, combined with the verbal root *san*, to say, it gives *san-o-ma*, a message; combined with the root *juo*, to drink, it gives *juo-ma*, drink; with the root *tek*, to do, it gives *tek-e-ma*, a deed; and many similar words, such as *luke-ma*, reading, and *laulo-ma*, song. In Aryan languages this formative is identically employed. Thus from the root *ghar*, to burn, we have in Sanskrit *ghar-ma*, warmth; and from *dhu*, to move, we have *dhu-ma*, smoke. In Lithuanian, from *vaz*, to carry, we have *vaz-ma*, carriage; from *aud*, to weave, we have *aud-i-ma*, a web. In Latin, from *fa*, to say (*fa-ri*), we have *fa-ma*, a report; and in Greek such words as τιμή and γνώμη. The comparison might be extended to other formative suffixes which are employed both in the Aryan and Finnic languages, such as *na*, *ja*, *va*, *la*, *ka*, *ta*, and *mine.* To take a few instances, we have in Finnic the formative *na*, which, combined with the verbal root *koh*, to drink, gives *koh-i-na*, drunken. In Sanskrit this suffix com-

* Thomsen, *Ueber den Einfluss der Germanischen Sprachen auf die Finnish-Lappischen* (Halle, 1870); Ahlqvist, *Die Kulturwörte der West Finnischen Sprachen* (Helsingfors, 1875); Schrader, *Sprachvergleichung und Urgeschichte.*

† Cuno, *Forschungen*, p. 52.

‡ Weske, *Entwickelung*, p. 5; Anderson, *Studien*, p. 108.

bined with the verbal root *svap*, to sleep, gives *svap-na*, sleep, and *sap-na*, sleep, in Lithuanian. In like manner the formative *ja* gives in Finnic *lug-e-ja*, a reader, from the root *lug*, to read; *laulo-ja*, a singer; *kakarda-ja*, a dipper: while in Lithuanian it gives *zyn-ja*, a magician, from the root *zin*, to know, and *sta-ja*, a position or place, from the root *sta*, to stand.*

When the stems have thus been built up by means of roots and formatives which are largely identical, and used in precisely the same way, conjugation and declension are effected by the same processes—declension by suffixed prepositions, and conjugation by tense-signs attached to the stem, and followed by pronominal suffixes.

Some of the tense stems are the same. Thus, both in Aryan and Finnic, we have tense-stems formed by *sk* and *ja*, and perfect stems by *s*.

The identity of the pronominal suffixes is still more important. For the first person the pronominal suffix was originally *ma*, which means "I" or "me," both in Aryan and Finnic. In modern languages, both Aryan and Finnic, this has become *m* or *n*, or has disappeared altogether. Thus from the verbal root *bhar*, to bear, we have in Sanskrit *a-bhar-am*, I bore, and in Greek ἔ-φερ-ον. The Old High German *two-m*, I do, and *ga-m*, I go, have become *thu-e* and *geh-e* in New High German. In Finnic the same pronominal suffix *ma* has undergone the same changes. Thus, in Tscheremiss, "I come" is *tola-m;* in Suomi it is *tule-n*, and in Esthonian *tul-e*. "I live" is *äle-m* in Lapp, *ale-n* in Suomi, and *el-ä* in Esthonian. The first person singular present from *lukea*, to read, is *luge-n* in Veps, *luga-n* in Lapp, *Luda-m* in Tscheremiss, and in Wotiak *lugo*, where the pronominal suffix has disappeared as completely as in the Latin *lego*. The pronominal suffix for the second person is *ta* in Finnic, which becomes *ti* and *t;* while in Aryan it is *tva*, which becomes *ta*, *tha*, *ti*, and *s*. Thus in Suomi we have *tule-t*, thou comest, and in Sanskrit *dadi-tha* (Latin *dedis-ti*), thou hast given.†

In the plural, as has already been explained, the order of the suffixes has been reversed, but their identity in Aryan and Finnic can be recognized. Thus, in Finnic, the suffix of the second person plural is *t-te*, as in *tule-t-te*, ye come. Here *t*, the plural sign, is followed by *te* (=*ta*), the pronoun of the second person. In Aryan, the order being reversed, the suffix of the second person plural was *ta-si*, where *ta* is the pronoun, and *si* the sign of the plural. Thus, in the Latin *ama-ti-s*, ye love, *ti* is the pronoun, and *s* the plural sign, the Finnic plural suffix *t* being probably the archaic form of the Aryan plural suffix *s*.

* For other instances, see Anderson, *Studien zur Vergleichung der Indo-Germanischen und Finnish-Ugrischen Sprachen*, pp. 107–109.

† Weske, *Entwickelung der Finnischen Sprachen*, p. 7; Pappillon, *Comparative Philology*, p. 161.

Thus the verb is conjugated in the same way in the Aryan and Ural-Altaic languages, the formation in both being, stem –|– tense –|– personal suffix; the Sanskrit future of the first person, *dat-as-mi*, giver-am-I, being constructed in the same way as the Ostiak future, *pan-de-m*, or the Turkic *yaz-ar-im*.

It is the same with the declension of the nouns. The case-signs in Finnic arose out of suffixed prepositions, as in the Aryan languages. Thus we have a Finnic ablative in *ta* or *t*,* which corresponds to the Aryan ablative in *at* or *t;* a Finnic locative in *ti*,† which corresponds to the Aryan locative in *dhi;* and a Finnic genitive in *n*, of which there are traces in Aryan genitives in *n* and *m;* and a Finnic accusative in *am* or *m*,‡ which is identical with the Aryan accusative. Thus, in Tscheremiss, we have the accusative *vida-m* from the stem *vida*, water, and in Sanskrit the accusative *pati-m*, master, from the stem *pati*.

These deep-seated structural agreements between the Aryan and Finnic languages are, as Penka admits, too profound to be explained by geographical contiguity, commercial intercourse, inroads, wars, or political supremacy. Penka accounts for them § by the supposition that Finnic is a mixed speech, which has been influenced by Aryan in much the same way that English has been influenced by Norman-French. But this hypothesis will hardly suffice to account for the fundamental agreement in the pronouns, the declensions, the conjugations, and the formatives. An explanation at once more simple and more satisfactory would seem to be that the Finnic languages exhibit a survival of the primitive form of speech out of which the Aryan languages were developed; the archaic semi-agglutinative Lithuanian approaching most closely to the Finnic, which is semi-inflectional.

Of the four neolithic European races one only can have been the primitive Aryan race. Two of them, the Slavo-Celtic and the Ligurian, are, like the Ugro-Finnic race, brachycephalic.

On archæological grounds we have arrived at the conclusion that the culture of the Slavo-Celtic race, as exhibited in the round barrows of Britain and the pile dwellings of Central Europe, comes nearest to that of the primitive Aryans as disclosed by linguistic palæontology. We have also seen that, anthropologically, this race belongs to the same type as the Finno-Ugric tribes of Eastern Europe and of Central Asia.‖ This conclusion is also in accord with the philological tests, which make it possible that Aryan speech may have been evolved out of a language of the Ural-Altaic class; the grammatical resem-

* Donner, *Die gegenseitige Verwandtschaft der Finnisch-Ugrischen Sprachen*, p. 62.

† *Ibid.*, p. 93.

‡ *Ibid.*, p. 73; Weske, *Untersuchungen zur Vergleichenden Grammatik des Finnischen Sprachstammes*, p. 39.

§ Penka, *Origines Ariacæ*, p. 68.

‖ See p. 53, *supra*.

blances pointing to a primitive unity of speech, just as the physical resemblances point to a primitive unity of race. There must have been some ruder form of speech out of which the elaborate Aryan inflection was evolved ; and there is no other known form of speech, except the Ural-Altaic, which can possibly be regarded as the germ out of which the Aryan languages may have sprung.

One possibility remains to be considered. Since the color of the hair and eyes is more variable than the shape of the skull, some anthropologists of repute, as we have already seen, are inclined to believe that the two brachycephalic races, the short, dark Ligurians, and the fair Celto-Slavic race, may be ultimately identified. We have also seen that the Basque probably represents the primitive speech of the former, and that it is also believed to belong ultimately to the Ural-Altaic family. We have also come to the conclusion that the Celto-Slavic race best represents the primitive Aryans, whose speech may have been evolved out of a language of the Ural-Altaic class. We may therefore conjecture that at the close of the reindeer age a Finnic people appeared in Western Europe, whose speech, remaining stationary, is represented by the agglutinative Basque, and that much later, at the beginning of the pastoral age, when the ox had been tamed, a taller and more powerful Finno-Ugric people developed in Central Europe the inflective Aryan speech. By this hypothesis many difficulties would be reconciled.

Ahlqvist has constructed a picture of the civilization of the undivided Finnic race by first eliminating the culture words which have been borrowed from the Aryans, and then distinguishing those which belonged to the Finns before their separation, by the test of their being the common possessions of the Western or Baltic Finns and the Eastern Finns of the Ural and the Volga. His reconstruction of the primitive Finnic civilization does not differ greatly from that which, on linguistic and archæological grounds, has been assigned to the undivided Aryans.

He comes to the conclusion that the undivided Finns were in much the same stage of culture as the Woguls, or the Ostiaks on the Obi, as described by modern travelers. They were nomad hunters and fishers, whose chief domesticated animal was the dog. The cow was not altogether unknown, but the art of making butter and cheese had not been acquired. The domestication of the sheep, the goat, and the pig was later than the contact with the Aryans. The name of the horse is an Aryan loan-word. Tillage was merely sporadic ; a patch of forest may have been cleared by fire, and a crop of barley grown. The dwelling, *sauna*, was a pit dug in the earth and roofed over, or a conical hut, *kota*, made of poles leaning against each other, or supported by a tree, and covered in winter by skins. These dwellings had a door and a hole in the roof, through which the smoke escaped.

The fire was built on a few loose stones in the middle of the hut, but there was no flooring and no window, light entering through the door or the smoke-hole in the roof. The women, with bone needles, made clothing from the skins of animals, and spun thread with spindles from the fibers of plants, while the men fabricated canoes, snow-shoes, and implements for hunting and fishing. If they had any knowledge of metals, it must have been confined to native copper.

It was only after the separation of the Eastern and Western Finns that they became acquainted with the sheep, and the art of preparing yarn from its wool. They had no towns, or judges, or hereditary chiefs.*

It will be seen that Ahlqvist's picture of the civilization of the undivided Finno-Ugric race, as derived from linguistic materials, differs little from that which Schrader has drawn of the culture of the undivided Aryans.†

According to Vambéry, the culture of the undivided Turko-Tartaric family was higher than that of the undivided Finns, but we must remember that the separation was much later. They knew the horse, the ox, the ass, the camel, and the sheep, as well as the dog, and they cultivated wheat and millet as well as barley.

CHAPTER VI.

THE ARYAN MYTHOLOGY.

NOT less remarkable than the silent revolution which has overthrown the once universally accepted hypothesis as to the successive migration of the Aryan nations from Central Asia, is the general abandonment of the expectation which was at one time entertained that India would interpret for us the meaning of the Teutonic, Roman, and Greek mythologies. We were told that "the Veda is the real theogony of the Aryan nations,"‡ and that "the mythology of the Veda is to comparative mythology what Sanskrit has been to comparative grammar." It was confidently proclaimed that the discovery of "the common origin of Greek and Sanskrit mythology" had already been made. It was compared to "the discovery of a new world;" and it was predicted that "the science of comparative mythology will soon rise to the same importance as that of comparative philology."§

The Sanskritists confidently produced their identifications. Aphrodite, Eurydice, Athena, Daphne, and Brynhild were all pronounced to be dawn maidens, and were identified with Urvasi; Heracles, Ares,

* Ahlqvist, *Kulturwörter der West Finnischen Sprachen*, p. 264.

† See p. 109, *supra*. ‡ Max Müller. *Essays*, vol. i, p 381. § *Ibid*, p. 449.

Achilles, Meleager, Orpheus, Balder, and Sigurd were solar heroes, and identified with Pururavas; the Greek Charites were the Indian Harits; and the Indian Maruts became the Roman Mars.*

No importance was attached to the objection that the Harits, the nine horses of Indra, did not in number, sex, form, or function bear any resemblance to the three graces, the Charites of Greek mythology. Helen, a dawn maiden stolen by Paris, was identified with the Vedic Sarama, who, instead of being himself stolen, recovers for Indra his stolen cows, which are the clouds of heaven. Professor Max Müller actually suggests that Achilles, a bright solar hero, is the Indian Ahalya, who is the goddess of the night beloved and destroyed by Indra.†

All such difficulties were overlooked, and we were told that the riddle of Aryan mythology had at last been solved. But these confident expectations have been doomed to be disappointed. Scholars were not more agreed as to the explanations from Sanskrit sources of the names of the Greek divinities than as to the order in which the Aryan nations started on their march from Central Asia. The explorations of neolithic graves, followed by the pamphlet of Johannes Schmidt, rendered untenable the hypothesis of the successive westward migrations of Aryan tribes; and in like manner George Smith's discovery of certain cuneiform tablets in the mounds of Nineveh upset the conclusions of the comparative mythologists, and falsified the confident prophesies which had been adventured by the too eager Sanskritists.

The key to the Greek mythology has indeed been found; but it has been discovered, not as was anticipated, on the banks of the Ganges, but on those of the Tigris. Much of the mythology of ancient Greece, instead of having a common origin with that of India, proves to be essentially non-Aryan, and must have been obtained from Babylonia through Phœnician channels. As might have been expected, the greater part of the Greek mythology proves to have been derived from the same source as the first elements of Greek culture. The rude barbarians of Hellas obtained their knowledge of gold and bronze, of weights and measures, of textile fabrics, spices, and jewelry, of the art of writing, and of the alphabet itself, from the Phœnician merchants who visited their shores; and in like manner, we now find that they obtained many of their deities and a considerable portion of their mythologic tales from the more cultured Semites. Mythologists were unable to explain why, if so many of the Greek myths were, as they affirmed, the common heritage of the Aryan race, so few of them could be traced in Italy or Germany. This riddle is now solved. They were not, as was supposed, a part of the common Aryan inheritance, but

* Cox, *Mythology of the Aryan Nations*, vol. i., pp. 32, 395–445.

† Mahaffy, *Prolegomena to Ancient History*, p. 51.

merely a foreign importation, at a comparatively late date, and confined to those portions of the Aryan territory which were frequented by Phœnician traders.

The clew, once obtained, has been followed up with marvelous success.

The great Semitic goddess Istar, primarily the moon, and afterwards the planet Venus, bore two characters, the chaste warrior-maiden, and the voluptuous deity of love. The Phœnician mariners brought her, in the latter character, and under the name of Astarte or Ashteroth, to Cyprus, whence, as the sea-born Aphrodite, her worship spread among the Greeks; while, probably by the land trade route through Asia Minor, the Babylonian Istar came to Ephesus as Artemis. Thus Aphrodite, instead of being an Indian dawn maiden rising from the sea, is now found to be the Babylonian moon goddess brought in Phœnician ships to Cythera and Cyprus.

When once the identity of Istar with Aphrodite and Artemis was established, it became easy, with the help of the Babylonian epic of the descent of Istar, recovered from the clay tablets of the library of Assur-banipal, to explain the significance of a considerable number of obscure Greek myths. The Phrygian myth of Atys and Cybele, and the corresponding Greek myth of Adonis and Aphrodite, was recognized as a mere Western version of the Phœnician myth of Tammuz and Astarte—the story of the moon mourning over the death of her lost spouse, the sun, and the name of Adonis was seen to be merely the Semitic Adonai, the "lord" of Heaven. And when Artemis was also identified with Istar, the Greek Amazons were seen to be the priestesses of the Asiatic goddess, the Galli were her eunuch priests, Istar being represented in Assyrian art with a quiver and a bow, just as Artemis is represented in the art of Greece.*

The bull, whose form was assumed by Zeus in order to carry off Europa, a Phœnician damsel, was seen to be the bull of Anu, the Semitic Heaven-god—the same bull which we recognize in the constellation Taurus, and Europa, the "broad-faced" maiden, is only another form of Istar, the broad-faced moon, instead of being identical with Urvasi, the Vedic dawn maiden.† The identity of the names was maintained on the ground that a Sanskrit *s* occasionally corresponds to a Greek *p*, though a suspicion that the Europa myth was of Phœnician and not of Indian origin might have been aroused by the fact that Europa is called the daughter of Phœnix—only another way of saying that the myth was derived from the Phœnicians.

Another myth, seemingly so diverse—the story of the slaying of the dragon by Perseus and the rescue of Andromeda—was localized by the Greeks on the Phœnician coast. It proves to be a lunar eclipse myth, ultimately Babylonian, a Greek translation of the Phœnician

* Sayce, *Hibbert Lectures*, p. 271. † Max Müller, *Essays*, vol. i., p. 406.

version of the combat of Bel Merodach with the dragon Tiamat, and the rescue of the moon goddess Istar from the black dragon who threatened to devour her.*

Another Tiamat myth is preserved in the Greek legend of the mutilation of Uranus by his son Cronus. This myth, which seems to us so repulsive, is merely a misunderstood translation from the Babylonian cosmogony, which represents Bel Merodach, the Semitic sun-god, cutting asunder his parent Tiamat, the primordial chaos from which he had sprung.

Ares, the warrior-god of the Greeks, has been identified by Professor Sayce† with Uras, the warrior-god of the Babylonians, whose title, "the lord of the pig," helps to explain an obscure Greek myth, which tells us that Ares slew Adonis by taking the form of a wild boar, the sun-god being slain by the tusk of winter.

The bold attempt of the Sanskritists to identify Mars (stem, *mart*) with the Vedic Maruts, who are the winds, presented the difficulty that the name of Mars was unknown to the Greeks, and even to the Iranians. It is, at all events, less plausible than the new explanation which identifies him with Mâtu or Martu, the Babylonian god who ruled the tempest, and was worshiped as Rimmon by the Syrians.

The theory of the Indian origin of the great Dionysiac myth was shaken by Lenormant's comparison of Dionysus with the Assyrian sun-god, who bore the name of Dianisu; and this was confirmed by Dr. Neubauer's identification of his mother Semele, daughter of Cadmus the Phœnician, with the Phœnician goddess Semlath, and with the Edomite "Semlah of the Vineland."

One of the greatest reproaches which the Sanskrit school of Comparative Mythologists had to bear was that in the Vedic hymns no trace could be found of Apollo, the great Hellenic sun-god, a deity reverenced more than any other by the Greeks. None of the myths of Apollo resembled the myths of any of the Indian sun-gods, and no explanation of the name was forthcoming from the resources of Aryan philology. If the Greek and Indian mythologies were parts of the common inheritance of the Aryan nations, it was strange that the name and worship of Apollo should be confined to those lands which were visited by the Phœnicians. But these mysteries have been at last explained. The oldest epigraphic form of the name of Apollo is Aplu, which corresponds to the Semitic Ablu, the "son" of Heaven, which was one of the titles of Tammuz, the Syrian sun-god. Heracles, again, is the Semitic sun-god under another aspect. His twelve labors are the twelve labors of Isdhubar, the Accadian hero, whose story may be read in the fragments of the great Chaldean epic which was redacted into a single whole many centuries before the Vedic hymns were first composed. The name of Heracles is of Greek invention;

* See Sayce. *Hibbert Lectures*, p. 102. † *Ibd.*, p. 153.

but Melicertes, the name which he bore in the Phœnician settlement at Corinth, is merely a Greek transliteration of the name of Melcarth, the Phœnician sun-god.

The very foundations of the Sanskritic school of interpretation being thus rudely shaken, scholars began to question other explanations which had been received with general acquiescence. Professor Max Müller, for instance, had identified Athena, the great deity of the Ionian Greeks, with the Vedic *dahana*, the "dawn" creeping over the sky. The philological difficulty was considerable, and scholars are now inclined to believe that Athena was not the dawn, but the lightning. Even the identification of the Centaurs with the Vedic Gandharvas has been questioned, owing to the discovery of Centaurs sculptured on Babylonian monuments.

Perhaps the greatest of the difficulties which beset the attempt to explain the Aryan mythology from Vedic sources was the almost complete discordance between the names of Greek and Roman deities. Juno and Hera, Venus and Aphrodite, Mars and Ares, Mercury and Hermes, Diana and Artemis, Neptune and Poseidon, Ceres and Demeter, are plainly unrelated names. If the Rig Veda explains so insignificant a portion of the mythology of the Greeks, whose language approaches Sanskrit much more closely than Latin does, it could hardly be expected that the mythology of Italy could be explained by that of India.

But it is now seen that many of the myths which were formerly supposed to prove the common origin of the Greek and Roman mythology are merely late and arbitrary transferences of mythic stories to wholly unrelated deities. Thus the adventures of Heracles, the Greek solar hero, which, as we have seen, are merely the borrowed adventures of the Babylonian Isdhubar, were assigned to Hercules, the old Italic god of inclosures, who has nothing in common with Heracles except an accidental phonetic resemblance of the name,* while Saturnus, the Italic god of agriculture, was identified with Cronus merely because his emblem, the sickle of the husbandman, resembled somewhat the sickle of Cronus, which is the curved scimitar with which Bel Merodach, the prototype of Cronus, combats the powers of darkness.

In like manner, the Greek myths relating to Aphrodite, which are mainly of Semitic origin, were boldly transferred by Ovid and other adapters to Venus, a purely Italic deity, of whose existence no trace can be discovered in Homer, Hesiod, the Avesta, or the Rig Veda, although the mere name can be explained as Aryan by help of the Sanskrit word *vanas*, which denotes that which is pleasant, especially pleasant drink,† and also sexual desire. Greek myths relating to Poseidon were also transferred to Neptune, whose name can be ex-

* Sayce, *Science of Language*, vol. ii., p. 262.

† Mommsen, *Romische Geschichte*, vol. i., p. 16.

plained by help of the Iranian word *napat*, water. In old Irish we have the word *triath*, which means the sea, and helps to explain the Greek Triton, the Sanskrit *trita*, and the Zend *thrita*. In all these cases the linguistic elements of the later mythologic names are primitive, but not the mythology itself.

These examples may serve to show that, while there was a common inheritance of language, any inheritance of a common mythology must be reduced to very small proportions. The names of the Aryan deities may be primitive words, but the mythological conceptions must be referred to a period later than the linguistic separation.

Setting aside the great Indian triad of Brahma, Siva, and Vishnu as being manifestly of late date, we find the Vedic gods of the first rank are Indra and Agni, after whom come Varuna and Mitra, Ushas and Surya. The great Hellenic gods are Zeus, Apollo, and Athena, followed by Poseidon, Hera, Aphrodite, Artemis, Hermes, Ares, Heracles, Demeter, and Dionysus. The great Italic deities are Jupiter, Juno, Mars, Minerva, Janus, Neptune, Diana, Pluto, Vulcan, Mercury, Venus, Hercules, Bacchus, and Ceres. The Teutonic deities were Thor, Odin, Freya, Balder, Tiu or Tyr, the god of war, and Frigga, the Earth, who is the wife of Woden, the Heaven. Among the Celts we have Ogma, Maponos, Segomo, Camulos, Toutates, Taranucos, Esus, Taranis, Cernunnos, and Nuada. The Letto-Slavic deities were Bogu, Perkunas, Perunu, Radegast, Swantowit, Potrimpos, and Picullas.

The diversity of these names is very striking, especially when we consider that they are all elemental. The Aryan nations, and many which are not Aryan, have personified the Heaven and the Earth and the Ocean, the Sun and the Moon, the Storm, the Thunder, the Lightning, the Dawn, the Fire, and the Wind. For these phenomena of Nature there were common names in the primitive Aryan speech, and hence the real matter for surprise is not that there is here and there a resemblance in the divine names of the different nations, but that the diversity should be so great.

They all reverenced and personified as the supreme deity the protecting vault of Heaven, but it was worshiped under different names —by the Indians as Varuna, by the Greeks as Zeus, by the Celts as Camulos, and by the Teutons as Woden. They all reverenced Mother Earth, the spouse of Heaven, but she was called Prithivi by the Indians, Gæa or Demeter by the Greeks, and Nerthus, Frigga, or Jördh by the Teutonic nations.

There is not a single power of Nature which can be proved to have been worshiped under the same primeval name by all the Aryan peoples.

The mythologists who affirm that the Greek and Indian mythologies have a "common origin," and that "the Veda is the real theogony of the Aryan nations," are encountered by two great difficulties. The first, as we have seen, is the fact that the mythologic names in Greek and Latin, and Latin and Celtic, do not agree; the second is that, though the connection of the Indians and Iranians is very close, the mythologic conceptions supposed to be common to the Indians and the Greeks are not also common to the Greeks and the Iranians. As a rule the Celtic divine names are confined to the Celts, the Latin names to Italy, the Slavonic names to the Slaves. Words relating to religion have a more restricted currency than those which refer to cattle, agriculture, and weapons. This leads to the presumption that the Aryans, before their separation, did not possess what can properly be called any common system of mythology. But this result is in accordance with the probabilities of the case. It has been shown that the primitive Aryans were not, as was formerly supposed, a semi-civilized race, who, in the bronze period, some fifteen centuries B.C., migrated from Asia into Europe, but that they were rather the lineal descendants of the neolithic people who had occupied Europe for unnumbered ages. Can it be supposed that these rude barbarians, clad in skins, ignorant of agriculture and metals, unable to count above a hundred, who practiced human sacrifice, were capable of elaborating a complex and beautiful mythology? Or, if they had invented it, is it likely that the names and adventures of dawn maidens and solar heroes could have been handed down orally in recognizable form through so many millenniums during which the art of writing was unknown? It is a question if there was any idolatry, properly so called, among the primitive Aryans. On the earliest monuments of the Egyptians and Babylonians we find sculptured representations of the gods. But there is no word for idol common to the Aryan languages, and no idols or objects of worship have been found in neolithic tombs,* or in the Swiss and Italian pile dwellings;† and even the Scandinavians had originally no images of their gods.‡

The Greeks owed to the Phœnicians the notion of representing the gods under human form,§ and images of the gods at Rome were first made by Etruscan artists. The earliest objects of Aryan worship seem to have been fetiches, such as sacred trees, belemnites, or meteoric stones.‖ The Jupiter Lapis of the Fetials at Rome was probably a belemnite. Artemis was worshiped at Ephesus as the stone which fell from Heaven, and the many-breasted representations of the goddess may have been suggested by the bosses found on meteoric stones. Zeus Cassius is represented as a stone on coins of

* See, however, De Baye, *L'Archéologie Préhistorique*, p. 95.

† Helbig, *Die Italiker in der Poebene*, p. 24.

‡ *Corpus Poeticum Boreale*, vol. i., p. 406.

§ Di Cesnola, *Cyprus*, Plate vi.

‖ Lang, *Myth, Ritual, and Religion*, vol. ii., pp. 219, 235; *Custom and Myth*, p. 223.

Seleucia in Syria, and the Paphian Venus appears under the form of a conical stone on coins struck in Cyprus.*

The earliest shrine of Greek worship was at Dodona, and here the object of worship was an oak, on whose branches charms and talismans were hung, and the whisperings of the wind in the leaves were regarded as the oracular voice of Heaven. It is plain that the culture of the undivided Aryans has been immensely overrated by the mythologists who have endeavored to prove that the theological conceptions of the Vedas, of the Edda, and of the Homeric poems were handed down from a pre-ethnic source.

The hypothesis of common traditions transmitted from the holoethnic period is not necessary to explain such resemblances as may exist in the mythological conceptions of the Aryan nations. It is more probable that somewhat similar myths were independently evolved as explanations of recurring natural phenomena. In all countries the day succeeds the night, the sky hangs over the earth, the sun and the moon pursue each other through the heavens, and the uprising of the sun is heralded by the tender dawn. Hence in all mythologies the day and the night, the heaven and the earth, the sun and the moon, the sun and the dawn, are represented as man and woman, either as lovers, or as husband and wife, or as brother and sister.

It is natural to represent the sun as a bridegroom coming out of his chamber in the east, and the dawn as a blushing maiden. Hence few mythologies are altogether free from the loves of solar heroes and dawn maidens. But it is not necessary to suppose that such myths are primitive.

The Indian *Ushas*, the Iranian *Ushanh*, the Greek ἠώς, the Latin *Aurora*, and the Lithuanian *Auszra*, all denote etymologically the glow of the rosy dawn, which was personified by Greeks and Romans, and deified by the Indians, but there are no common myths. The Vedic Surya, the spouse of Ushas, is etymologically the same as the Greek Helios, the Latin Sol, and the Welsh Heul (Howel), but Eos is associated in Greek myth with Kephalos and Tithonus, and not with Helios. The connection is merely linguistic, not mythologic, and the solar heroes and dawn maidens were plainly evolved after the Aryan separation.

The divine names which go back to the primitive period are all names of the powers of nature, and in dealing with such early words it is impossible to say whether the names may not have referred merely to the phenomena of nature rather than to any divine personifications, which may have arisen independently at later periods.

Scanty as are the mythologic names common to any two of the Aryan families of speech, the significance of these few agreements

* Evans, *Ancient Stone Implements*, p. 9.

tends to disappear on closer examination. Indra and Agni are the deities who occupy the highest places in the oldest Indian mythology. This is evident from the fact that of the most ancient hymns in the Rig Veda 265 are addressed to Indra, and 233 to Agni, and not more than 60 to any other god.* But supreme as is the position of these two dieties in the most ancient records of Aryan religion, their worship is practically confined to India. In the European mythologies their place is taken by Zeus and Woden, Apollo, Thor, and Balder. In the Avesta there is barely a vestige of the great name of Indra, nor can it be traced in any of the European languages.

In the Vedic hymns Agni is second only to Indra in importance, and much has been made of the etymological identification of the name of Agni with the Latin *ignis* and the Lithuanian *ugnis*; but this amounts to very little. It merely proves that the undivided Aryans were acquainted with fire, but it does not prove that fire was an object of worship. The inference is rather that the worship of the sacred fire arose after the separation of the Aryans. We find that in India Agni was a chief object of worship at the earliest time of which we have any cognizance of Aryan religion, but there is no reason to believe that fire was ever worshiped under this name by Latins or Lithuanians.

The presumption is rather the other way, since the Roman fire-worship was addressed to Vesta, the tribal fire of the domestic hearth, while Agni among the Indians was quite another thing—the sacrificial or celestial fire.

The Greek Hestia, it is true, agrees in name and function with the Latin Vesta;† and this is the most striking of all the correspondencies between Roman and Greek mythology, more especially since there is reason to believe that Vesta was the oldest of the deities of Rome. But there is no trace of this venerable worship in India. In Sanskrit the name only exists as *vastu*, which merely means the house or dwelling place.

The very fact that the Vesta worship is the most indubitable of the correspondencies between the Greek and Roman mythologies is itself a proof of the rudimentary nature of their common civilization. Only among the rudest of existing savage tribes, such as the Australians, is it held a duty to keep alight the fire of the tribe, which if extinguished has to be obtained from some neighboring tribe, as they are ignorant of the means of rekindling it. The Chippeways and Natchez Indians had an institution for keeping alight the tribal fire, certain persons being set aside and devoted to this occupation;‡ and the incorporation and endowment of the Vestal Virgins at Rome seems to be a survival of a similar practice, the social duty, originally devolving on the

* Keary, *Outlines of Primitive Belief*, p. 126.

† Preller, *Griechische Mythologie*, vol. i., pp. 227–333; *Romische Mythologie*, p. 532.

‡ Lubbock, *Prehistoric Times*, pp. 464, 537.

daughters of the house, obtaining a religious sanction as the service of the perpetual flame.

The name of Prometheus, who, according to the Greek myth, brought fire from heaven to mortals, may be explained by the Sanskrit *pramantha;* but this word did not become a mythological term among the Indians, but merely denoted the drill by which fire was obtained by friction. Here clearly the mythological conception is later than the separation of Greeks and Indians, and we are only entitled to conclude that the fire-drill was known before the linguistic separation. Hence the whole of the evidence tends to the belief that the most primitive of all worships, that of fire, does not belong to the earliest period, but was independently evolved among the Eastern and Western Aryans.

The gulf between the Teutonic and Celtic languages is much wider than that between Indian and Iranian; but, as has been already shown, the culture words prove that the relations of the Celts and Teutons were those of later geographical contact and political supremacy. There are reasons for supposing that a considerable portion of the Teutonic mythology may have been obtained from Celtic sources, as that of the Greeks was obtained from the Semites. Professor Rhys believes that the myths relating to Woden, the great Teutonic sky-god, may be traced to a Celtic origin, and he compares the name of Woden with the Celtic Gwydion.* But as no parallel name and no parallel myths are to be found among the Italic races, who stand in a much closer linguistic relation to the Celts than the Celts do to the Teutons, these myths probably date not from the time of the Celto-Teutonic unity, but from the much later period when the Teutons lived under the political supremacy of the Celts.

Thor or Dunar, the Teutonic thunder-god, may also be compared with the Celtic thunder-god Taranucus (Welsh *taran*, thunder); and Professor Rhys finds Toutiorix, the Gaulish Apollo, in the legends of the German solar hero Theodoric, and he connects the Gaulish Esus with the Teutonic Anses and the Norse *æsir*—a word which is applied to the gods generally, and may be etymologically explained by the Sanskrit *asus*, the breath of life. He also compares the Teutonic Mars, Tiu, the "glorious" or splendid one, with Llud (King Lud), who is Nuada of the silver hand under another name. The name Nuada, originally Nodens, may be compared with the Italic Neptune, which is written Nethuns on an early mirror. The Celtic Heaven-god Camulos corresponds etymologically to the Teutonic Himmel, and his functions are those of the Greek Uranus, but Heaven was worshiped by the Teutons as Woden and not as Himmel.

Kuhn thinks that Sarama, the messenger of Indra, was the wind; Professor Max Müller, with less reason, claims him as the dawn; and

* Rhys, *Hibbert Lectures*, p. 283.

he may perhaps be identified, at least etymologically, with the Greek Hermes, the messenger of Zeus. The Vedic Ushas, the morning red, is etymologically the Greek Eos and the Latin Aurora, and the Vedic Surya is etymologically the Latin Sol.

Other suggested identifications between mythological beings in Greece and India are between Phlegyas and Bhrgu, Trita and Triton, Phoroneus and Bhuranyu, the Centaurs and the Gandharvas, and between the lovely Saranyus, who is the morning dawn, and the gloomy Erinyes, the implacable Furies of the Greeks.

But some of these identifications are etymological rather than mythological, and others are rejected by the best scholars. It is possible, however, that there may be a connection between Janus and *Ζάν*, Juno, and *Διώνη*.

Professor Max Müller has attempted to identify the Indian Maruts with the Roman Mars. But in the Greek mythology, or even in the Iranian, which is so much closer than the Latin to that of the Indians, we have no trace of Mars or Maruts, and we are driven to conclude that the evolution of the Maruts was subsequent to the separation of the Indians and the Iranians, and indefinitely later than the separation of the Italic and Indian races, and the identification of Mars (Martis) with the Babylonian storm-god, Mâtu or Martu, is, to say the least, as probable as is any connection with the Indian Maruts. Not only the Maruts, but Rudra and the other Indian deities associated with Indra are unknown in the Avesta. Brahma, who afterwards replaced Indra as the supreme Indian god, appears in the Rig Veda, and so also does Vishnu; but Siva and Kali, who now occupy such a prominent position in Indian worship, are unknown, and are probably of Dravidian origin.

When we have diligently read all the bulky volumes which have been written with the object of identifying the deities of India and Europe, it is surprising to find how scanty are the actual results which are accepted by all scholars. This has been well put by Mr. Lang,* who says that Mannhardt, after having been a disciple of the Sanskritist school, has been obliged to confess that comparative mythology has not borne the fruit that was at one time expected, and that those gains of the science which may be considered certain, reduce themselves to the scantiest list of parallels—namely, the Indian Varuna and the Greek Uranus, the Indian Bhaga and the Slavonic Bogu, the Indian Parjanya and the Lithuanian Perkunas, and, finally, the Indian Dyaus and the Greek Zeus. Mannhardt adds that a number of other equations, such as Sârameya and Hermeias, Saranyus and Erinys, Gandharvas and Kentauros, will not stand criticism, so that these ingenious guesses will prove mere *jeux d'esprit* rather than actual conclusions of science.

* Lang, *Myth, Ritual, and Religion*, vol. i., p. 23.

But even the four identifications which Mannhardt believes to be actually established are more or less illusory. If Varuna, Bhaga, Parjanya, and Dyaus were deities worshiped by the undivided Aryans, we should expect to find these names in the whole circle of the Aryan languages, just as we find the names for mother, wife, and daughter, for dog, cow, wagon, and wheel, for five and ten. But this we do not find. Dyaus is the only name which is at all widely spread ; and even in the case of Dyaus, the strongest of all, there are reasons which may make us doubt whether he can ever have been the supreme god of the undivided Aryans.

The case of the Sanskritists rests on these four Indian names: Bhaga, Parjanya, Varuna, and Dyaus. The real significance of these four names will, therefore, have to be examined more closely.

The Norse Fjörgyn was identified by Grimm * with the Lithuanian thunder-god Perkunas, and probably with the old Slavonic Perunu ; but Professor Rhys considers as futile the attempt to connect them with the Sanskrit Parjanya, the god of rain and thunder. The Mordwin thunder-god Porguini is doubtless the same as Perkunas; but this may be set down as a case of mythological borrowing, and there is no trace of such a deity in Greek or Latin.

In the Slavonic languages Bogu denotes the supreme deity. The word is found in the Rig Veda as *bhaga*, which means the distributor of gifts, especially of food, and is used as an epithet of the gods, and also, seemingly, as the name of a subordinate deity. In the Avesta the word has attained a larger significance, and is applied as an epithet to Mithra, and also to Ahura-Mazda, who is called Bhaga-Bhaganam, god of gods.† The word only became the name of the supreme deity among the Slaves, and among the closely related Phrygians, with whom, according to Hesychius, the word *Βαγαῖος* was the equivalent of Zeus. The inscription, *Jovi Baginati*, inscribed on a Gaulish altar found in the Department of the Isère, was probably a dedication by Persian or Phrygian mercenaries, as there is no other indication that such a name belonged to the Celtic Pantheon.‡

Bogu and Perkunas must therefore be set aside as divine names, which had only a limited geographical currency, and may be ranged with other culture words of late date which are common to the Iranian and Slavo-Lettic languages.§

The comparative mythologists who assert that the undivided Aryans were in possession of a common mythology before their separation have, therefore, to rest their case on to equations—that of the Indian Varuna and the Greek Uranus, and of the Indian Dyaus with the

* Grimm, *Deutsche Mythologie*, p. 156.

† See Cook, *Origins of Language and Religion*, p. 69.

‡ Rhys, *Hibbert Lectures*, p. 54.

§ See p. 195, *supra*.

Greek Zeus, the Latin Jupiter, and the Teutonic Tiu.* The identification of Varuna and Uranus, although from an etymological point of view it leaves nothing to be desired, fails to prove the contention, because it is confined to Sanskrit and Greek; and we have already seen that the Greeks and Indians share late culture words, such as those for certain weapons, and for implements of tillage, which are not found in other Aryan languages—an indication of a geographical contact posterior to the linguistic separation of the Aryans. But there is this great difference, that, while the Indo-Greek culture words are found also in Iranian, the Indo-Greek mythologic names are significantly wanting. This defect in the Iranian record is the more specially significant, because the separation of the Indians and Iranians was later than that of any of the other Aryan families, and also because the religious ideas of the Rig Veda agree in so many minute particulars with those of the Avesta. The Indians and Iranians, as we have already seen,† had a common religious ritual; they had common names for priests, sacrifices, sacred chants, for the soma drink, and for religious aspergation—a clear proof that an organized system of worship had been developed before the separation. There are no such ritualistic agreements between any of the other Aryan families. The agreement in the mythologic system is also so close and striking that if we find mythologic names in Greek and Sanskrit, but not in Iranian, it is difficult to believe they are really primitive, and not evolved independently by Greeks and Indians.

To give a few instances, we find that in the Avesta Mithra's club is called Vazra, while in the Veda Indra's club is Vajra. The cloud demon slain by Indra is Vritra, the demon slain in the Avesta is Verethra. In the Avesta, Vayu, the wind rides in a golden chariot; in the Veda, Vayu is Indra's charioteer. Azhi-dahaka, the biting serpent of the Avesta, is the serpent Ahi of the Veda. The Thrita and Thrætona of the Avesta are the Trita and Traitana of the Veda.‡ The mighty warriors and far-ruling kings of the Avesta are in the Veda the ancient spirits of the sky.§ Yama, who was originally merely the setting sun, is, like the Egyptian Tum, exalted in the Veda to be the king of the dead, while in the Avesta he has become the first legendary Iranian monarch. The Indian sun-god Mitra became among the Iranians the gracious Mithra, the "friend" of mankind. Mitra is associated with Varuna as Mithra is with Ahura. Ahri-man, the destructive spirit, appears in the Veda as well as in the Avesta.

Asura and Mazda are titles given in the Veda to Varuna; but in the Avesta these two titles are combined as the proper name of the supreme God, and we have the magnificent conception of the Ahura

* See, for instance, Max Müller's article on "The Lesson of Jupiter" in the *Nineteenth Century*.

† See p. 190, *supra*.

‡ Duncker, *History of Antiquity*, vol. v., p. 42.

§ *Ibid*, p. 44.

Mazda (Ormuzd), the "Lord Omniscient," whose all-seeing eye is the glowing orb of day, whose son is the fire, while the robe which clothes him is represented as the vast starry firmament, which also is the garment of the Indian Varuna.

It is plain that while the lower mythological ideas of the Indians and Iranians agree, the higher religious conceptions, involving the name of the king all glorious above, "whose robe is the light, whose canopy space," were the creations of a later time, when Indians and Iranians had separately advanced out of the earlier barbarism to a higher and nobler intellectual culture.

But Ahura Mazda, the supreme deity of the Iranians, was not the supreme deity of the Indians, though they gave the corresponding title Asura Medha to more than one god of light.* The supreme Indian deities were Indra and Varuna, of whom there is hardly a trace in the Avesta—a tolerably sure proof that the Indian worship of Varuna, the mighty Heaven, was evolved after the separation of the Indians and Iranians.

That this was the case is confirmed by the fact that the agreements between the Indian and Greek mythology, of which so much has been made, are nominal rather than real.

Both in India and Greece we have the common linguistic germs of the later mythological conceptions, but the mythology itself is plainly a later growth. The names of Uranus and Varuna are etymologically identical, as are those of Zeus and Dyaus, but this is all that can be affirmed. Indra and Varuna in the Vedic hymns completely take the place and offices of Zeus in the Homeric poems. Varuna is the mighty deity who rules the universe, who listens to human prayers, who does the right, and decides the destinies of men; while Indra, like Zeus, is the wielder of the thunderbolt. Nor does the Greek Uranus correspond more closely to Varuna. As Ludwig has observed, such Homeric phrases as *οὐρανὸς ἀστερόεις* show that in the oldest literature of the Greeks the word Uranus designated only the physical vault of heaven, and it is not before the time of Hesiod that Uranus is personified, and becomes the spouse of the earth and the ancestor of Zeus; whereas in India, at a much earlier time, Varuna has become the supreme administrator of the universe, and is never identified with physical phenomena.* Dyaus, however, in the Veda is still what Uranus was in Homer, and has not yet become what Zeus was among the Greeks.

It is true that the Indian Dyaus is the same word as the Greek Zeus, while the Latin Ju-piter, the Teutonic Tiu or Ziu, and the Celtic *duw* are names of kindred origin. Hence by far the strongest case is that of Zeus, since this is the only divine name which is found in any con-

* Duncker, *History of Antiquity*, vol. v., p. 145,

* See Cook, *Origins of Religion and Language*, p. 66.

siderable number of Aryan languages. But even this widespread appellation is not universal. It is not found among the Iranians and the Slaves, and where it is found the mythologic equivalence is questionable.

In the first place, if Dyaus had been recognized as the highest god, or even recognized as a god at all, by the undivided Aryans, or if he had occupied among the Indians the supreme position which Zeus held among the Greeks, it is difficult to understand how every trace of the worship of such a mighty being should have disappeared among the Iranians, whose separation from the Indians was so late, and who agree with them so closely in their religious observances and their mythological beliefs.

While the name of Dyaus does not even appear in the Avesta, in the Rig Veda he occupies a wholly subordinate position, completely overshadowed by Varuna. Indeed, he can hardly be called a god; he is little more than the sky, the physical germ of a mythological conception, just as Uranus was at first among the Greeks. Indra is called a son of Dyaus, a child of Heaven, in the same way that Zeus is said to have been one of the grandchildren of Uranus; but Dyaus can hardly be said to have been an object of worship among the Indians any more than Uranus was among the Homeric Greeks. Far less can Dyaus be claimed as the supreme Heaven-god, which Zeus was among the Greeks.

It is easier to believe that Zeus was elevated by the Greeks themselves to his exalted position, and that the personification of Dyaus was later than the separation of Indians and Iranians, than to hold, with Professor Max Müller and others, that the lofty Greek conception had belonged to the half-savage Aryans before the linguistic separation, and that this great primeval faith had almost died out in India, and that in Persia it had altogether disappeared.

But if we once admit that before the separation of the Aryans they had a common name for the sky, as well as for the water and earth, all the difficulty disappears. Not only did the word *dyaus* mean little more among the Indians than the mere physical sky, but even among the Greeks and Romans there are linguistic survivals which prove that the development of the mythological ideal was still comparatively recent. When the Greeks said *Ζεὺς ὕει*, "the sky pours down rain," there was still an evident consciousness in the ancient phrase that the word *zeus* had once meant the physical sky and nothing more. That the same was the case among the Romans is shown, among other instances, by the well-known line of Horace, "Manet sub jove frigido venator" (the huntsman abides under the chill sky). Plainly, among both Greeks and Romans, Zeus and Jove had not altogether ceased to be regarded, like the Indian Dyaus, as the over-arching heaven.

All, therefore, that we can safely conclude is that before their linguistic separation the Greeks and Indians had common names for the sky, Dyaus and Varuna, and that the mythologic significance of these names may date from a later period, and have been independently evolved.*

There is a further difficulty in supposing that Zeus was the god of the undivided Aryans. Not only is the name wanting in the Iranian and Slavo-Lettic languages, but in Celtic, which is so closely related to the Latin, we find only the germ from which such a conception might have been developed. In the Celtic languages no god bears this name, but we find words derived from the same root, *div*, to "shine," from which we get the Sanskrit *diva* and *divasa*, day; the Armenian *div*, "day;" the Latin *dies;* and the Celtic *diu*, *dieu*, and *dyw*, "day." This root is also the source of the Latin *divus* and *deus*, and of the Celtic *duw* and *dia*, a god.† To the same source we may attribute the Iranian *dæva*, which denoted a demon, or evil spirit.

The fortunes of this word in the Teutonic languages are of more importance. So much has been made of the supposed identity of the Sanskrit Dyaus and the Teutonic Tiu or Ziu, and the identity, if it could be established, would have such far-reaching consequences in its bearing on the primitive culture of the undivided Aryans, that the question must be examined in some detail.

Of the German mythology we know little, but the mythologic lore of the Scandinavians has come down to us in considerable amplitude; and, since the Low German Tiu and the High German Ziu was undoubtedly the same deity as the Scandinavian Tyr, it will suffice to inquire whether Tyr can be identified with Zeus, or whether he was an independent mythological creation.

Now, in the earliest Scandinavian literature, *tyr* (plural *tivar*) is only a divine appellation, meaning simply "a god." Thus Thor is called Reidi-tyr, the car-god; Odin is Hanga-tyr, the gallows-god, or Farma-tyr, the cargo-god. In the plural we have Sigtivar, the gods of victory, and Val-tivar, the gods of those slain in battle. The word *tivar*, remotely related to the Latin *deus*, means properly "the glorious ones," being formed from a root denoting splendor, glory, fame (proto-Aryan *div*, to shine), which is seen in the word *äsc-tir*, spear-fame, or renown in battle.‡

In the later Scandinavian mythology we find this word appropriated as the proper name of a secondary deity, represented as a somewhat comic personage, whose arm was bitten off by the wolf Fenris, whose

* In like manner, when, in the later Greek mythology, Uranus had been at last personified, the Iranian *Asman*, the heaven, became among the Greeks Ἄκμων, the father of Uranus.

† Rhys, *Hibbert Lectures*, p. 119, maintains that the Celtic word never acquired the force of a proper name.

* Kemble, *The Saxons in England*, vol. i., p. 353.

wife was unfaithful to him, and who is mocked for his misfortunes by the other gods, like Hephæstus in the Greek mythology.* He is simply the glorious one, the one-armed god of victory, in no way corresponding in his place or functions to the Greek Zeus, but rather to Mars or Ares. That he was thus identified by our forefathers is shown by the fact that the Teutonic Tues-day is not Jeudi, *Dies Jovis*, but Mardi, *Dies Martis*. The Teutonic Tiu may have a remote linguistic relation to Zeus, but mythologically he corresponds to Ares. In the Teutonic mythology the true analogue to Zeus or Varuna is not Tiu or Tyr, but Woden or Odin,† who is the supreme Heaven-god, the blessed Father, the Lord of Earth, the All-Father of gods and men, whose consort is Jördh, the Earth, whose all-seeing eye is the sun, the round orb which is also the eye of Ahura Mazda and Varuna, beholding all things upon earth.

Thor, the thunderer, is not the son of Tyr, but *Odins sonr* and *Jardhar sonr*, the son of Heaven and Earth, just as Indra, who answers to Thor, is the son of Varuna. The Anglo-Saxon royal families trace their descent from Woden, not from Tiu, just as noble Greek families did from Zeus. And Frigg, the Mother Earth, is the spouse of Woden, not of Tiu.

If Tiu or Tyr had been mythologically related to Zeus, he would in all these aspects have taken the place of Odin. The Baltic tribes possessed the obvious mythological conception of Father Heaven and Mother Earth, but it was wholly independent of the Jupiter and the Demeter of the Mediterranean nations. The mythologists have been led astray by the similarity of the names to infer an identity of Tiu and Zeus, which in reality had no existence. The real "Lesson of Jupiter" is the lesson that philology by itself may be a misleading guide.

But though the All-Father of our Teutonic ancestors was Woden and not Tiu, it has been urged in the article to which reference has just been made that the identification of Zeus and Dyaus is made complete, since we find Dyaus designated as Dyaush-pitar in the Veda, which corresponds to the Latin Diespiter, or Jupiter, and to the Greek Ζεὺς πατήρ (vocative Ζεῦ πάτερ). This, doubtless, is plausible and tempting; but it is by no means certain that such designations belong to the primitive period, and may not have arisen independently. We have no trace of such a compound appellation as Dyaush-pitar or Jupiter among Celts, Lithuanians, Iranians, Slaves, or Teutons; whereas, granting that Dyaus or Zeus was a primitive name of the sky, the notion of regarding Heaven and Earth as the parents of gods and men is so obvious and universal that there is no difficulty in supposing that it may have arisen independently among Indians,

*See the "Loka-Senna" in Vigfusson and Powell's *Corpus Poeticum Boreale*, vol. i., p. 106.

† See *Corpus Poeticum Boreale*, vol. ii., pp. 459, 460.

Greeks, and Latins. In fact, we find the same idea in almost all mythologies. In New Zealand the Maoris regard Rangi, the Heaven, and Papa, the Earth, as the universal parents of all things.* The Peruvians, the Caribs, the Aztecs, the Red Indians, the Finns, the Lapps, and the Anglo-Saxons all spoke of Mother Earth, and sometimes the Sun, or more usually the Sky, was regarded as her spouse. Among the Finns, Ukko and Akka are the names given to Father Heaven and Mother Earth.† Among the Greeks it was sometimes Uranus and Gæa, sometimes Zeus and Demeter, who were so regarded. So also, in the Rig Veda, Dyaus, who is the physical heaven, is called Dyaush-pitar, Father Sky, who with Prithivi-matar, Mother Earth, are the parents of the Supreme God, the mighty Indra.

It may, therefore, be questioned whether Dyaus was ever the supreme Heaven-god of the undivided Aryans. They clearly had two words for the sky; the bright sky of day was called Dyaus, "the shining," and the over-arching canopy of night was called Varuna, the "coverer" or "concealer." From these physical conceptions the names of the supreme deities may well have been independently evolved. In the dark West and the cold North the daylight sky was reverenced as the supreme source of good; in the burning and torrid Eastern lands the covering sky of night and Indra, the lord of rain, were rather looked up to and invoked as the blessers of mankind.

In India and in Greece, just as among Red Indians and Maoris, Father Heaven and Mother Earth were regarded as the primeval parents of all things, or the sun and moon were looked upon as brother and sister, or as a wedded pair; or the sun would be pictured as an ardent youth chasing a fair maiden, the flying dawn. The chariot of the sun, the winds—the invisible messengers of Heaven—would be images occurring independently to the poets of both nations; and, since the words denoting the sky and the dawn and the heavenly bodies would be related words, the few coincidences in mythological names may be explained without the hypothesis of a primitive Aryan mythology, invented in remote neolithic times, and handed down in recognizable form from the far-distant period when the Aryan peoples parted.

But though the common origin of the Greek and Indian mythology, once so confidently asserted, has wholly, or in great part, to be surrendered, we are able to see more clearly what it was that was really common to Greeks and Indians. In India, as in Greece, there was the same over-arching sky, the sun and the moon and the stars, the storm-clouds and the wind, the same succession of day and night, of summer and winter, and all the mysterious phenomena of nature. And there were the elements of a common speech; there were men

* Tylor, *Primitive Culture*, vol. i., p. 290; Lang, *Custom and Myth*, p. 48.

† Castrén, *Finnische Mythologie*, pp. 32, 86.

calling all these things by related names, thinking the same thoughts, speculating in the same way as to celestial phenomena, so that as culture progressed among Indians and Greeks, Teutons, Celts, and Latins, nature-myths, with features essentially the same, but underived, were independently evolved, as an attempt to explain the aspects of the world.

But if the Aryans started without mythological beliefs, and merely with common words for day, sky, and brightness, it is easy to see how these words should have independently become the names of the supreme Heaven-gods. From the root *div* or *dyu*, to shine, we obtain a whole series of Aryan words, denoting day, and noon, and sky, heavenly and divine, god and goddess; and, finally, the names of specific deities were evolved. Such are, in Greek and Latin, the names *Διαίνη* and *Διώνη*, Divania and Diana, Djanus and Janus, Djovis and Jovis, Zeus; and such words as *hora meri-diana*, *jove diano*, *sub dio*, *ἐν δῖος*, at noon, *deus*, *divus*, *δῖος*, divine; in Welsh *dyw*, a day, and *duw*, a god; in Irish *diu*, a day, *dia*, a god, and *de*, a goddess; and in Armenian *div*, day.*

But even if we admit the identification of the Greek Zeus with the Indian Dyaus—and this is by far the strongest case—we may affirm, with Professor Rhys, that the so-called Science of Aryan Comparative Mythology, which started so long ago with this identification, cannot in all these years, be said to have advanced much further; and it seems doubtful whether even this identification is of the genuine mythologic order, and not merely linguistic.

It is surely easier to believe that rude, uncultured nomads, still in the stone age, should not have risen to the conception of the Hellenic Zeus than that such a conception, if it had existed, should, as they rose in culture, have been degraded to the mere physical conception; and it is equally difficult to understand how the name and worship of the supreme Heaven-god should have been lost utterly among the Iranians and the Slaves.

As Professor Rhys remarks: "If the Aryans had attained to the idea of so transcendent a god . . . there would be a difficulty in understanding how, as the Dyaus of Sanskrit literature, he should have become comparatively a lay figure; that as Tiu he should have been superseded by Woden and Thor among the Teutons, and that among the Gauls his pre-eminence should at any time have been threatened by a Mercury."† Ideas may be the same, and language may be identical, but we cannot affirm that the undivided Aryans were in possession of a common mythology. It is more probable that, out of the same common words and the same thoughts, the Aryan nations, after their separation, constructed separate mythic tales, whose resemblances are apparent rather than real.

* See Rhys, *Hibbert Lectures*, p. 116. † *Ibid.*, p. 110.

Another factor has also to be taken into account. Much of the culture formerly attributed to the undivided Aryans is due, as we have seen, merely to borrowing; and so also, it is probable, that there has been an extensive migration of myths from tribe to tribe. In many cases this has been proved to be the case. We know that a large portion of the Greek mythic tales were in reality derived from Semitic sources; that the Latin poets transferred Greek myths to unrelated Italic deities; that the Teutons appropriated Celtic deities, while even the mythology of the Edda turns out to be largely infected with ideas which can be traced to Christian sources, and supposed Hottentot traditions of a universal deluge prove to have been obtained from the dimly-remembered teaching of Christian missionaries.

Religious myths, like folk-tales and popular fables, have an astonishing faculty for migration. Sacred legends of the Buddhist priests found their way from India to Bagdad, from Bagdad to Cairo, from Cairo to Cordova, and are now enshrined in the pages of La Fontaine, having been translated by wandering professional story-tellers from Pali into Pehlevi, from Pehlevi into Arabic, from Arabic into Spanish, from Spanish into French and English.

It is more probable that any divine myths which may ultimately be identified in the Aryan languages may have thus migrated at some early time, than that, as the Comparative Mythologists assume, they formed part of the common Aryan heritage in the barbarous and immensely remote period before the linguistic separation. In any case it is clear that the sweeping conclusions which were in vogue thirty years ago as to the nature and extent of the primitive Aryan mythology are based upon assumptions as unwarranted as the theories of the successive migration of the Aryan nations from the East.

The work of the last ten years has been mainly destructive. The work of the previous half-century has been revised, and ingenious but baseless theories have been extensively demolished, and the ground cleared for the erection of more solid structures.

While on the one hand science has been specialized, on the other it has been shown that the correlation of the prehistoric sciences is as intimate as the correlation of the physical sciences. The whilom tyranny of the Sanskritists is happily overpast, and it is seen that hasty philological deductions require to be systematically checked by the conclusions of prehistoric archæology, craniology, anthropology, geology, and common sense.

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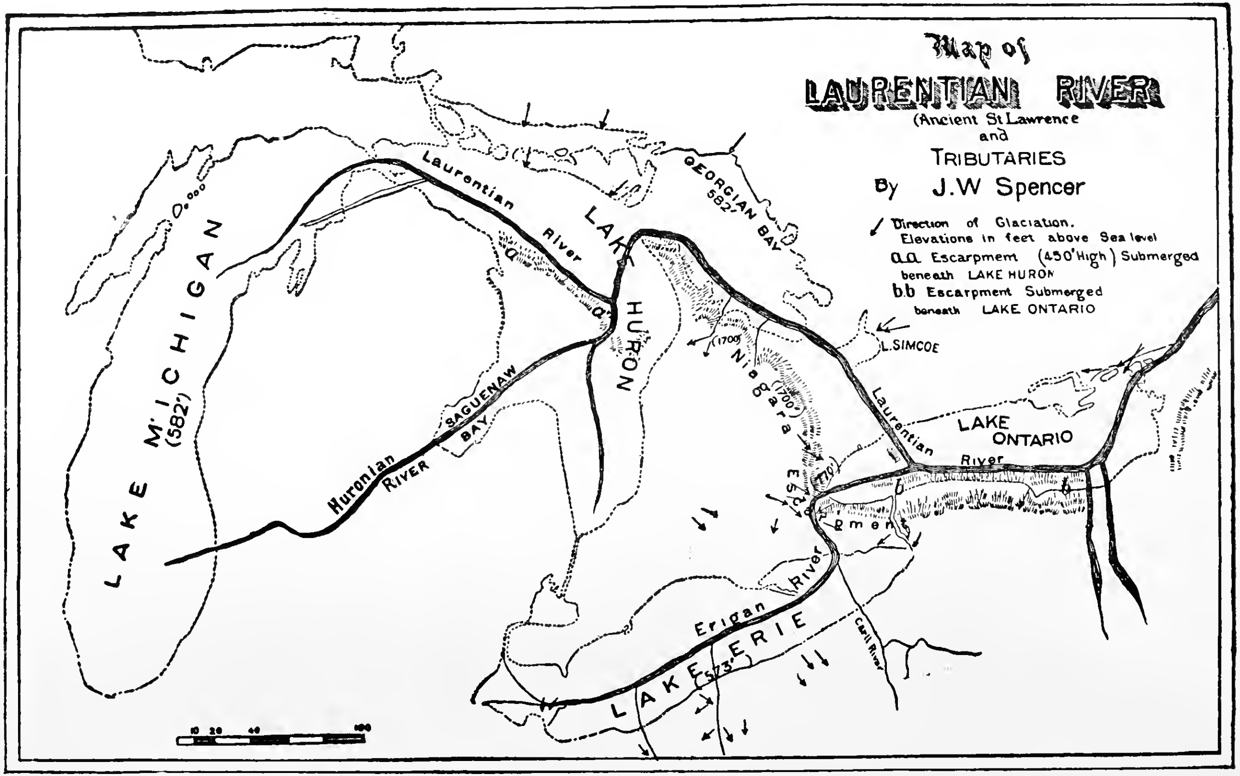
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THE ORIGIN OF ALPINE AND ITALIAN LAKES; AND UPON GLACIAL EROSION

INTRODUCTION.

WITH NOTES UPON THE ORIGIN OF THE AMERICAN LAKES.

BY J. W. SPENCER.

CONSIDERING the youth of the science of Geology, it is not remarkable that the serious study of Glacial Phenomena dates back scarcely more than half a century, and that of the lakes, so characteristic of the scenery of the Alps, Scandinavia, North-eastern America, and Central Africa for only half that time. It has been during the last decade, that there has been shown the greatest interest in the investigation of the phenomena that have contributed to the moulding of the physical features of the northern parts of the American continent, and hence the necessity of importing the literature of kindred European questions to this country.

The efforts made, nearly thirty years ago, by Mortillet, and especially by Ramsay, to explain the origin of the Alpine lakes by glacial erosion, formed the beginning of the new epoch in the investigations of lacustrine geology, and of the excavating power of glaciers. However, the extravagant views of Sir A. Ramsay rendered a service to science, in that it awakened an interest in the causes which fashioned our lakes, and many features of our landscapes. The consideration of the glacial origin of the lakes is so locked up with that of glacial erosion in general, that neither question can be investigated alone. Accordingly the following papers bear alike upon both lines of enquiry.

Many of the exaggerated views of Ramsay and other authors have been bodily transferred to America, and some of them have been carried farther than was proposed by their authors. The result is that American literature is often replete with tyrannical assumptions not based upon observed facts. The closet geology is rapidly giving place to that of the field, and the last two or three years show wonderful progress in the investigations of the architecture of our Continent. Although the views of Sir A. Ramsay are now greatly modified, still they formed an epoch in investigations, which we have not yet entirely passed. The epoch making of his papers, and the investigations that they developed, are accordingly sufficient reason for commencing the following compilation with his studies.

In the speculations upon the origin of the Alpine lakes and valleys, Professors Ramsay and Tyndall attempted each to refute the conclusions of the other. In doing thus, each an extreme glacialist, brought out facts that caused the other to be overthrown, without the interference of those men who do not see in glaciers great erosive power. For this discussion, see the subjoined paper by Mr. Whymper. However, the writings of Sir A. Ramsay and Dr. Tyndall have done great service in bringing out classic papers, which have thrown a flood of light upon the origin of lakes and the question of glacial erosion. These papers were published in journals difficult of access to present investigators and intelligent readers, who of necessity have had to be content to remain in ignorance of them, or to accept only such reference as may chance be quoted, mostly by their opponents. Such being the case, and as a knowledge of the Alpine lakes and glacial erosion are as necessary to the American student as to the European, the editor has compiled some of the most valuable papers upon these subjects, so as to render them accessible to the American reader. To those on Alpine geology, there is appended "Glacial Erosion in Norway and High Latitudes," which adds to our knowledge of glacial action, in a manner not set forth in the other papers. The conclusions of the older contributors, as seen in the following chapters, have been extended by many subsequent investigators, whose papers cannot be here added. Suffice it to say that most Continental geologists are in sympathy with the papers published in reply to that of Sir A. Ramsay, which is, however, rich in facts.

The investigations conducted by the present editor, upon the origin and history of the Great Lakes of America, have yielded results in perfect harmony with the conclusions deduced from the facts set forth in most of the following papers on Alpine lakes. The conclusions from the American investigations, as to the origin of the lake basins (their history is not here considered) may be briefly stated: The Great Lakes are the product of the excavation of the valley of the ancient St. Lawrence and its tributaries, at a time of high continental elevation, followed by continental oscillations during the Pleistocene period, which have left the basins of the lakes down to or below sea-level, but holding in the waters by rocky barriers or folds, owing to subsequent warping of the earth's crust, transverse to the original valley. This transverse uplift across the valley was recognized, in the Alps, twenty-five years ago, by Mr. Ball, whose general conclusions were adopted by Prof. E. Désor and a dozen Swiss geologists. The evidence of this warping, about the American lakes is to be found in the old sea-cliffs, and in the beaches, from which the waters have long since receded. Besides this warping of the earth's crust, which forms barriers across the ancient valleys, the lake-basins have in part been closed by drift deposits. That the American lakes were not ploughed out by glaciers is abundantly proven, even if the warping were not known; for throughout several of them, there are the remains of old escarpments, (recognized in the soundings), which bordered the old river. Again the course of the ancient St. Lawrence, between Lake Ontario and Georgian Bay has been discovered beneath a deep accumulation of drift. Finally as conclusive proof, the glaciation of the whole region is not along the line of the troughs, but at angles (amounting to even right) to and against the faces of the escarpments fronting the lake-basins. The accompanying map shows the course of the Laurentian, or ancient St. Lawrence River, as discovered by the Editor from the soundings in the lakes and from deep borings through the drift. But the Origin and History of the American Lakes will form a volume by itself.

As the original papers upon the Alpine lakes throw so much light on the study of the American, so the value of the actual glacial erosion in Europe can be transferred to the investigations of the surface geology of the Lake regions. Glacial geology is based upon observations of the action of European glaciers. Consequently the arguments of theorists who despise or ignore those teachings of the European glaciers, which are unfavorable to their philosophy, and appeal to unknown action in greater Arctic ice masses, which few have studied even exteriorily, and none can interiorly, is simply illogical. So far as is known, the greater ice masses act like the lesser, but with somewhat intensified results, yet flowing more easily owing to the greater weight. Even in the greater masses, there is as yet no proof that the glaciers can tear loose subjacent rocks or lift them to thousands of feet above their birth-places. In the lake regions of America, there are raised beaches, some of which are now known to have been formed at sea-level, but which contain no shells of any kind. The absence of organic remains is no proof of their fresh-water origin, as some extremists assert, nor of their marine origin. In Georgia and Alabama, there are old Pleistocene sea-shore deposits, and these gravels and sands contain no more organic remains than those about the Great Lakes, nor many conglomerates and sands of Palæozoic or Mesozic age, nor, indeed, of many stretches of modern sea-shores. Hence, when we are told that certain beaches are of fresh-water origin, because of the absence of shells, the lesson taught is valueless.

As will have been seen, the origin of the Great Lakes of America is found primarily in modification of ancient valleys by orographic movements of the earth's crust.

UNIVERSITY OF GEORGIA, Dec. 1889.

I.

ON THE GLACIAL ORIGIN OF CERTAIN LAKES IN SWITZERLAND, THE BLACK FOREST, GREAT BRITAIN, SWEDEN, NORTH AMERICA, AND ELSEWHERE. BY SIR A. C. RAMSAY, F.R.S., PRESIDENT OF THE GEOLOGICAL SOCIETY, ETC.

Erroneous Theories of the Transport of Alpine Blocks.—In the year 1859, in a series of papers by the members of the Alpine Club, I published a memoir in which I compared the old glaciers of North Wales with those of Switzerland; and in it, among other matters, I explained the glacial origin of certain rock-basins now holding lakes, on the watersheds and in the old glacier-valleys of both those countries; and in a later edition of the same memoir, published as a separate book, with additions,* I extended these generalizations to many of the lakes in Sutherlandshire.

In the same work I also expressed an opinion that the blocks of Monthey, in the valley of the Rhone, and the great erratic boulders that strew the southern flank of the Jura had been transported by icebergs derived from glaciers which descended in the Alpine valleys to the sea-level, during a period of submergence in which the low country that lies between the Jura and the Oberland was covered with erratic drift.

There was nothing new in this latter opinion, for it had previously been held by several distinguished geologists, both English and continental.

Since then I have twice revisited Switzerland, and have seen good reason to change my opinion respecting the cause of the transport of erratic blocks to Monthey and the Jura, and of *débris* not remodelled by rivers, &c., that lies scattered over the lowlands of Switzerland, or that borders, or lies in great mounds well out in, the plain of Piedmont and Lombardy. I am now convinced, for example, that the vast circling moraine of Ivrea, noticed by Studer in 1844, was shed from a glacier, 105 miles in length, that filled the valley of Aosta to a height of more than 2000 feet, and protruded far into the plain; while on the north a still greater

* The Old Glaciers of North Wales

glacier, long ago described by Charpentier, flowed from the valley of the Rhone right across the low country until its end abutted on the Jura. As there are still many persons in England who doubt these conclusions, it may not be beside the question to state the considerations that led me to reject the old theory.

Reasons for abandoning the older theories.—I first began to doubt the correctness of my earlier opinions in the summer of 1860, while examining the country near Bonn, the banks of the Moselle, and the Eifel. Neither in the valleys nor on the wide table-lands on both sides of the Rhine and the Moselle is there any sign of glacial drift. Excepting alluvial *débris* in the valleys, the native rock is generally quite bare of transported detritus; and the only marks of glaciation lie low on the sides of the Moselle, where the floating down of the river-ice has frequently rounded, polished, and striated the rocky banks in the direction of the flow. Boulders, transported from further up the stream, also sometimes lie on the shores. But, in the absence of true drift, I considered that, had Switzerland been depressed at least 3000 feet, until its mountains were washed by a sea that floated transported blocks to the higher Jura, the table-lands of Rhenish Prussia and Westphalia would also possibly have been submerged, and more or less covered with glacial detritus. Further up the Rhine and in the Black Forest the same absence of marine drift prevails. There, looking eastward towards the Rhine, the mountains, chiefly of gneiss, are wonderfully scarred, telling the observer of the wasting effects of frost, ice, rain, and rivers, probably ever since the close of the Miocene period. In the valley of Oberweiler, between Mullheim and the watershed, I observed occasional heaps of moraine-like detritus, in which by diligent searching I fouud a few stones marked with the familiar glacial scratchings.

In the interior towards Schonau and the Belchen, the rocks being generally soft and schistose, no very decided signs of old glaciers occur, and no part of the country shows symptoms of the presence of drift. Allogether the country looks as if it had stood in the air for so great a period that, even if glaciers were once present, they had disappeared so long that all the more prominent signs of degradation are now due to rain and running water. But further in the interior it is altogether different; for the signs of old glacier-ice are plentiful enough, and for miles round the Feldberg, which rises 4982 Baden feet above the sea, the sides of the valleys to the very summits of the mountains are often strikingly *moutonnées*, though the rounded forms are generally roughened and frequently half ruined with age. On these, striations, though rare, may occasionally be discovered (running in the direction of the valleys), although the rapid rate at which the rock weathers is much against their preservation. Moraines also are not uncommon. At the foot of the Feldberg, on the east, there is a beautiful circular lake, called the Feldsee, surrounded by tall cliffs of gneiss and granite in the shape known in Scotland as a corrie—a form eminently characteristic of all glacier-countries past or present. The outer side of the lake is dammed up by a perfectly symmetrical moraine, curving across the valley, and formed of sand, gravel, and of granite and gneiss, often in large boulders. It is now covered with pine-trees. The lake is deep, and the moraine rises from 25 to 40 feet above the water. Outside the moraine lies a flat marsh, still retaining traces of having been a lake, once also dammed by a second and outer moraine, formed chiefly of large angular blocks of gneiss, piled irregularly on each other like the old moraine of Cwm Bochlwyd, above Llyn Ogwen in Caernarvonshire. Quantities of moraine-matter strew the valley for two or three miles further down to the little marshy lake at Waldbauer. which is also dammed up by moraine-rubbish, in one place rudely stratified, like some of the old moraine-heaps on the Jura and parts of the great moraine of Ivrea; or like the heaps of glacier-*débris* that often border the lakes, marshes, and flat peat-mosses, once lakes, that diversify the lowlands of Switzerland. At the upper end of the Alb Thal also, at the entrance of Menzenschwanden Alb, I saw four moraines curving across the valley, arranged concentrically one within another, like those at the end of the glacier of the Rhone; and for many miles in the Alb Valley, both above and below St. Blasien, *roches moutonnées* stand like islands through the alluvium, while it is also plain that the sides of the mountains above have been to a great height smoothed by ice. Nowhere however down to Allbruck, where the river joins the Rhine,* did I see any "drift;" and this village lying close on the north side of the Jura, it seemed impossible that the higher ground on the south side of that range, between the Lakes of Constance and Geneva, should have been submerged during any part of the Glacial period, while the country on the Rhine above Basel remained above the sea. I therefore saw that the theory that the *Pierre à bot* and its companion blocks had been floated from the Alps by marine icebergs was untenable; and a later examination of a portion of the Jura, partly under the able guidance of Professor Désor, fully convinced me that the ice that descended the great valley of the Rhone had covered much of the low country and abutted on the south-eastern flank of the Jura.

Old Distribution of the Great Alpine Glaciers.—At that period, then, of extreme cold, when the glaciers of the Alps flowed right across the Miocene basin of Switzerland, a glacier of vast

* Between Basel and the confluence of the Aar and the Rhine.

thickness (No. 1 on the Map, Pl. VIII.), running from end to end of the upper valley of the Rhone, debouched upon the lowlands at what is now the eastern end of the Lake of Geneva, and spreading in a great fan-shaped mass extended to the south-west several miles down the Rhone below its present outflow from the lake, and north-east to the banks of the Aar, about half-way between Solothurn and Aarau. The length of this fan-shaped end of the glacier, from north-east to south-west, was about 130 miles, and its extreme breadth about 25 miles. Another great glacier (No. 5) descended in a direction opposite to the higher part of the Rhone glacier, through the upper valleys of the Rhine, and debouched upon a wide area that extends from Kaiserstuhl on the Rhine, far to the north-east. In the centre of this area lies the Lake of Constance. Between these, which were the largest glaciers on the north watershed of the Swiss Alps, several smaller, but still enormous, glaciers flowed in a north-westerly direction from the mountains,—one down the Linth, through the area now occupied by the Lake of Zurich (No. 4), another down the Upper Reuss, across the area in which lie the Lakes of Lucerne, Zug, and others (No. 3), and a third down the valley of the Aar to Berne, through the country that now contains the Lakes of Brienz and Thun (No. 2). According to this view (the result of the researches of the best Swiss geologists), the greater part of the Swiss Miocene area lay deep under ice, and I am inclined to think that the country between the great old glaciers of the Reuss, Aar, and Rhone was much more covered with ice than any map shows, the whole helping to swell the prodigious glacier of the Rhone that abutted on the Jura.

Connection between Tarns and Glaciers.—In "The Old Glaciers of North Wales" I have shown that in all glacier-countries, whether past or present, there is an intimate connection between tarns and glaciers. Some of these are dammed by old moraines, but the greater number lie in *rock-basins*, formed by the grinding of glacier-ice as it passed across the country, whether in valleys, on rough table-lands, or on the watersheds of passes. These lakes and pools are of all sizes, from a few yards in width, lying amid the mammillations of the *roches moutonnées*, to several miles in diameter. Sometimes in the convolutions of the strata (conjoined with preglacial denudation subsequent to the contortion of the beds), softer parts of the country may have been scooped out, leaving a hollow surrounded by a frame-work of harder rock; but perhaps more generally they were formed by the greater thickness and weight, and consequently proportionally greater grinding pressure, of glacier-ice on particular areas, due to accidents to which it is now often difficult or impossible to find the clue.

Trifling as this phenomenon at first sight may seem, I yet believe the manner of the formation of these lakes is of much importance to the right understanding of the glacial theory, whether taken in connection with the great extension of extinct glaciers in recognized glacier-regions, or, further, when viewed on a general continental scale; for *the theory of the glacial origin of many rock-basins* must, I feel convinced, be extended much beyond such mountain-districts as Switzerland, Wales, and the Highlands of Scotland, where they first attracted my attention.*

Origin of the Great Alpine Lakes. Subject stated.—From the consideration of the origin of mountain-lakes and tarns, the question easily arises,—What are the causes that have operated in the formation of the great lakes of Switzerland, such as those of Geneva, Zurich, and Constance, and, south of the Alps, of Maggiore, Lugano, Como, and others? To answer this with precision, it will be necessary, first, to examine several other hypotheses that by some may be thought sufficient to account for them.

It is well known that after the close of the Miocene epoch the rocks of the Alps were much disturbed,—a circumstance proved by the contortion of the Miocene strata, as for instance in the neighborhood of Lucerne, where, on the Rigi (and in other conglomeratic mountains on the same strike), the strata are considered by the best Swiss geologists to be repeatedly folded and fairly inverted, so that the basement-beds form the top of the mountain instead of its bottom, thus, by reversal of dip, plunging under the Eocene and Cretaceous strata of the mountains further south. The whole, as shown by the rapid truncated foldings and the escarpments of the hills, has since been much denuded, the denudation being of a kind and amount that, to effect it, proves the lapse of a long period of time. Witness the outliers of Miocene strata in the upland valleys of the Jura. Among these disturbed and denuded strata of Miocene and of older dates, the Lakes of Geneva, Thun, Brienz, Lucerne, Zurich, Constance, the Wallen See, and the great lakes of North Italy lie. A knowledge of the stratigraphical structure of the Alps, in my opinion, proves that these lakes do not lie among the strata in basins merely produced by disturbance of the rocks, but in hollows due to denuding agencies that operated long after the complicated foldings of the Miocene and other strata were produced.

First, none of these lakes lie in simple synclinal troughs. It is the rarest thing in nature to find an anticlinal or a synclinal curve from which some of the upper strata have not been removed by

* It is not to be supposed that I attribute the origin of all rock-basins to glacial action. Many lie in the craters of extinct volcanos, some, no doubt, in areas of special subsidence, and others may be due to causes of which I know nothing. I now confine my remarks to certain lakes common in all highly glaciated regions such as I know.

denudation. I never yet saw a synclinal curve of which it can be proved that the uppermost stratum in the basin is the higher layer of the formation that was originally deposited over the area before the curving and denudation of the country took place. The only approach to this may possibly be in the upper valleys of the Jura, where a part of the Miocene beds lie in basins separated by secondary anticlinally curved strata, the tops of the anticlinal bends having been removed by denudation; but these cases are surrounded with difficulties. The lake-hollows in the Alps are, however, encircled by rocks, the strikes, dips, and contortions of which often exhibit denudation on an immense scale; and in no case is it possible to affirm, here we have a synclinal hollow of which the original uppermost beds remain. If these beds have disappeared to a great extent, then it is evident that denudation has followed disturbance. The fragmentary state of the uppermost Miocene strata of the lowlands of Switzerland proves this denudation. Again, if it be argued that in the lake-areas these denudations have been produced by the waters of the lakes, it is replied that, though waves may form cliffs, neither running nor still water can scoop out deep trough-shaped hollows.

Secondly, the same kind of argument applies to areas of mere watery erosion by rivers. Running water may scoop out a sloping valley or gorge, but (excepting little swallow-holes) it cannot form and deepen a profound hollow, so as to leave a rocky barrier all round; though it may fill with sediment one that had previously been formed.

Thirdly, neither do most of the Swiss lakes lie in lines of dislocation. For many reasons I do not believe that any one of them among the high Alps or on their flanks can be proved to lie in lines of mere gaping fracture. Let us consider the nature of such fractures.

In any country where the strata are comparatively little disturbed and lie nearly horizontally, if it be faulted, there is no reason why the fractures should be open. In the Oolites, for example, in the South of England, where faults are numerous, and in the New Red Sandstone of the central counties, there is generally a simple displacement of the strata up or down, on one side or the other; or, if the disturbance go beyond this, it is that along the sloping line of fracture the beds on the downthrow side are turned up, and those on the opposite side bent down, by pressure and slipping combined. In more disturbed districts, like the Welsh Coal-measures, the same phenomena are observable: witness, for instance, the numerous sections from accurrate observation, drawn on a true scale, by Sir Henry De la Beche, Sir William Logan, and others. Experience both above ground and in mines proves the same. Most lodes are in fractures, and many lie in lines of fault. In metamorphic, excessively contorted, and greatly fractured districts like those of Devon, Cornwall, and Wales, the cracks, whether bearing metals or not, vary from mere threads to a few fathoms in width. They are always filled with quartz or other foreign substances, frequently harder than the surrounding matrix. I have often traced lodes on the surface, in Wales, by the hard matter filling the crack standing in relief above the surface of the softer enclosing rock. In limestone rocks the cracks are usually partly filled with crystallized carbonate of lime. Lines of fracture are not, therefore, for purposes of denudation, necessarily lines of weakness, unless it happen that on opposite sides of the fault hard and soft rocks come together, when of course the softer rocks will wear away more rapidly, and generally originate a straight valley.

Again, in an excessively contorted country, such as the Alps, it is, I believe, impossible, *in consequence of that contortion*, that there should be gaping fractures now exposed to view. Assuming for the sake of argument the sudden violent contortion of the strata of any great tract of country, we shall see that the contorted rocks *now exposed at the surface*, even if broken, would be most unlikely to gape.

The expression "elevation of mountains" conveys to the minds of many persons the idea that the elevation has been produced by some force acting from below, along a line in the case of a chain, and on a point of greater or less extent when the mountains lie in a cluster, as a whole, more or less dome-shaped. Such forces would stretch the strata; and when they could no longer stand the tension, cracks would ensue, and many lines of valley are assumed to lie in such fractures. But in Wales, the Highlands of Scotland, and more notably in the Alps, the strata now visible have been compressed and crumpled, not stretched, and they occupy a smaller horizontal space than they did previous to the formation of the chain.

Let us suppose a set of strata of (say) 14,000 to 20,000 feet in thickness, like the rocks of North Wales, and let these be spread out horizontally over thousands of square miles. Let these strata, from any cause, be compressed from the right and left so as to be contorted, and occupy a smaller horizontal area that they did before disturbance. Then, at a great depth, where the superincumbent strata pressed heavily on the lower beds, the latter would be crumpled up, cleavage would often supervene, and gaping fractures would be impossible; for, where mere fractures occurred, the walls of the cracks would be pressed more closely together. But nearer the surface, where there was less weight, and at it, where there was none, the beds would extend into larger curves than they did lower down; and where the limits of extensibility were passed, shattering might take place, and yawning chasms might ensue. In all violently contorted countries, however, as in the cleaved rocks of North Wales, for instance, the present surface shows those originally deep-seated contortions that since disturbance have been exposed by denudation; otherwise the rocks would not be cleaved. I therefore do not believe that in any country I have seen, such as Wales or Switzerland, there are any lakes now occupying yawning fractures, consequent in Switzerland on post-eocene or post-miocene disturbances. On the contrary, they lie in hollows of denudation, shortly to be explained, of later date than these disturbances.

Fourthly, again, it may be supposed that the great lakes lie each in an area of special subsidence; but, in reply to this, it is evident that among the unnumbered lakes of Switzerland and the Italian Alps it would be easy to show a gradation in size, from the smallest tarn that lies in a rock-basin to the Lakes of Geneva and Constance. Neither do I see any reason why mere size should be considered the test of subsidence. Disallowing that test, we should require a great number of special subsidences, each in the form of a rock-basin, in contiguous areas. Between the Seidelhorn and Thun, for example, we should require one for the Todten See, several on the plateau on the north immediately under the Seidelhorn, one for the lake at the Grimsel, another for the drained lake at the Kirchet,* and another for the lakes of Brienz and Thun. In Sutherlandshire these areas of special subsidence would be required by the hundred, and in North America by the thousand.

Signor Gastaldi, in a masterly memoir on the composition of the Miocene conglomerates of Piedmont,† considers with reason that the large augular blocks of these strata, many of them far-transported, and some of them foreign to the Alps and Apennines, have been deposited from ice-rafts; and thence he infers the existence of glaciers during a part of the Miocene epoch. But, admitting this, it is evident that the distribution of the post-pliocene glaciers of the Alps must, in all details, have been quite different from those of Miocene age, in consequence of the great disturbance that the Alpine rocks underwent after the close of the Miocene epoch, and the subsequent formation of numerous new valleys of denudation. Traces of the long lapse of time between the Miocene and the later Glacial epoch are in other countries but imperfectly preserved in the subdivisions of the Crag, and of other minor formations of still later date. Of the finer gradations that unite these subdivisions few traces have been described. For long before, and during all these Crag epochs and the ages between them, of which we have little trace, and during all the time that elapsed from the close of the

*See the "Old Glaciers of Switzerland and North Wales."

†"Sugli elementi che compongono i conglomerati Mioceni del Piemonte." Turin, 1861.

Crag until the period of extreme cold came into action, the Alps stood above the sea, and, suffering subaërial denudation, valleys were being formed and deepened. It is possible that, while the mild climates of the Lower Crag epochs endured, there may still have been glaciers in the higher Alps; but at whatever period the later glaciers commenced, those who allow the extreme slowness of geological change will admit that the period was immense that elapsed during the gradual increase of the glaciers, until, in an epoch of intensest cold, the ice abutted on the Jura in one direction, in another spread far beyond the present area of the Lake of Constance, and on the south invaded the plains of Lombardy and Piedmont. During all that time weather and running water were at work modifying the form of the ground under review. But, as I have already explained, these two agents were incapable of scooping out deep hollows surrounded on *all* sides by rocks, and it therefore follows that the lakes first appeared after the decline of the glaciers left the surface of the country exposed approximately as we now see it,—unless we admit, what seems to me impossible, that fractures, formed at the close of the Miocene epoch, remained filled with water until the great glaciers filled them with ice; or believe, with De Mortillet, that the valleys and lake-hollows were charged with water-borne alluvial or diluvial *débris* before the glaciers ploughed it out.*

Allowing the hypothesis of De Mortillet, the rock-basins must have been twice filled with water; but, according to my hypothesis, they did not exist as lakes till after the disappearance of the glaciers.

But the glacier map of ancient Switzerland shows that the areas now occupied by the great lakes, both north and south of the Alps, have all been covered with glaciers. No tertiary deposit of an age between the close of the Miocene and the commencement of the Glacial epoch lies between the Alps and the Jura; and, had the hollows of the lakes existed prior to the great Glacial epoch, we ought, but for some powerful wasting agent, probably in these hollows, still to find some traces of freshwater deposits, perhaps of the age of part of the Crag. No such relics exist.

The Great Lakes. Lake of Geneva.—The Lake of Geneva is about 45 miles in length by about 12 in breadth, and its delta, once part of the lake, between Villeneuve and Bex, is 12 miles long. The latter and a small part of the banks of the lake beyond the mouth of the river lie in the great Rhone valley, formed of older Tertiary and Secondary rocks. All the rest of the lake is surrounded by the

* See an admirable memoir by G. de Mortillet, "Des Anciens Glaciers du Versant Italien des Alpes." Milan, 1860. Though I had seen his map, I had not seen this memoir when I read my paper; and the passages in which it is mentioned have been added as these pages passed through the press. His theory leaves the difficulty of the first formation of the basins untouched, unless we believe (which I do not) that the Alpine valleys are lines of fracture.

low country formed of the various subdivisions of the Molasse and Nagelfluh. The lake is 1230 feet above the level of the sea, and 984 feet deep towards the eastern end, according to the soundings of De la Beche.* See fig. page 19.

Geneva itself stands on superficial *débris;* but the solid rock first appears in the river-bed below Geneva, at Vernier, at the level of 1197 feet above the sea—only 33 feet below the surface of the lake, or 951 feet above the deepest part of its bottom. Any one acquainted with the remainder of the physical geography of the country will therefore see that the water of the lake lies in a true rock-basin. The question thus arises, How was this basin formed?

1st. It does not lie in a simple synclinal basin; for, though the Lake of Geneva lies in the great synclinal hollow of the Miocene strata between the Alps and the Jura, it is evident by an inspection of the country that the flexures of that formation are of far greater antiquity than the lake, These flexures have been denuded, and the lake runs in a great degree across their strike.

2nd. For reasons already stated, it is, I believe, impossible to prove that the lake lies in an area of special subsidence, all the probabilities being against this hypothesis.

3rd. It is almost needless to say that the Lake of Geneva is too wide to lie in a mere line of fracture; and I know of no reason why the valley of the Rhone, where occupied by the delta, should be esteemed a line of fault or gaping fissure, any more than many other valleys in Switzerland, which many geologists will consider with me chiefly the result of the old and long-continued subaërial denudation of highly disturbed strata. I could enter on details to prove this point, but they belong rather to the rock-geology of Switzerland than to the matter in hand.

4th. Those who do not believe in the existence and excavating power of great and sudden cataclysmal floods will at once see that the area of the lake cannot be one of mere watery erosion; for ordinary running water, and far less the still water of a deep lake, cannot scoop out a hollow nearly 1000 feet in depth.

Now, if the Lake of Geneva do not lie in a synclinal trough, in an area of subsidence, in a line of fracture, nor in an area of mere aqueous erosion, we have only one other great moulding agency left by which to modify the form of the ground, namely, that of ice.

When at its largest, the great glacier of the Rhone (No. 1 of the Map), debouched upon the Miocene beds where the eastern end of the Lake of Geneva now lies. The boulders on the Jura, near Neuchâtel, at the point on the Map marked B, prove that this glacier

* Edinburgh Philosophical Journal, 1820, vol. ii. p. 107, and plate 2

Fig. 1.—*Outline-map of the Lake of Geneva, showing the principal Soundings in English feet.* (*After Sir H. De la Beche, F. R. S.*)

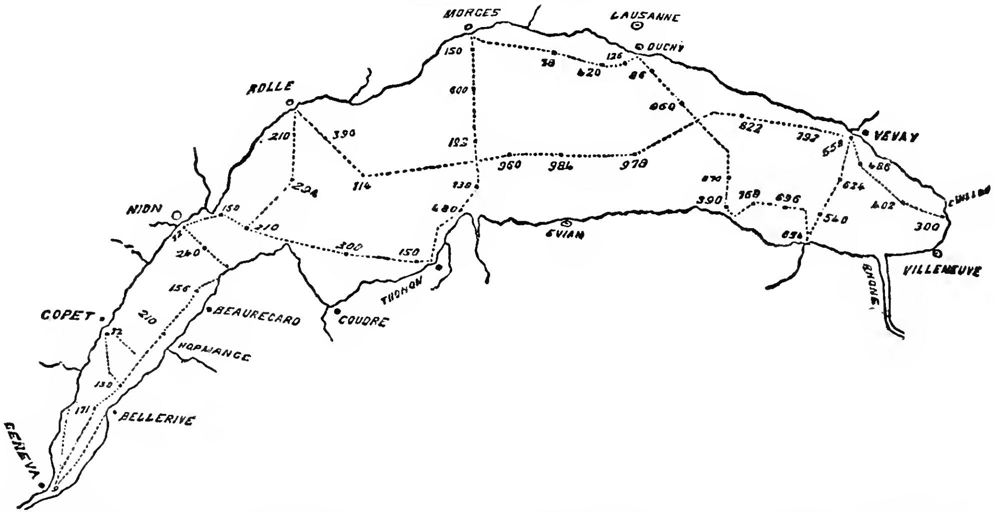
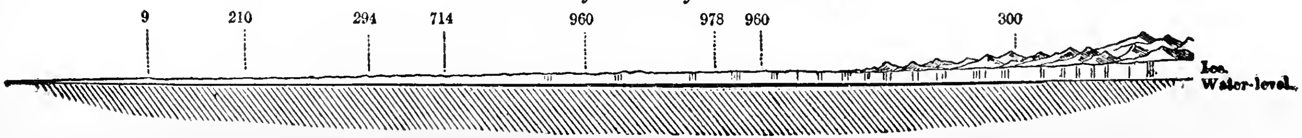


Fig. 2.—*Diagram-section of the Lake of Geneva, with Soundings in English feet, and showing the Comparative Thickness of the Ice of the Old Glacier.*



was about 2200 feet thick where it abutted on the mountains; and, where it first flowed out upon the plain at the mouth of the valley of the Rhone, the ice, according to Charpentier, must have been at least 2780 feet thick.* Add to this the depth of the lake, 984 feet, and the total thickness of the ice must have been about 3764 feet at what is now the eastern part of the lake, fig. 2.† I conceive, then, that this enormous mass of ice, pushing first north-west and then partly west, scooped out the hollow of the Lake of Geneva most deeply in its eastern part opposite Lausanne, where the thickness and weight of ice, and consequently its grinding power, were greatest. This weight decreasing as it flowed towards the west, from the natural diminution of the glacier, possessed a diminishing eroding power, so that less matter was planed out in that direction, and thus a long rock-basin was formed, into which the waters of the Rhone and other streams flowed when the climate ameliorated and the glacier retired.

Lake of Neuchatel.—The basins of the Lakes of Neuchâtel, Bienne, and Morat were, I consider, hollowed out in a similar manner, differing in points of detail. Near the Lake of Neuchâtel, on the flank of the Jura, the fan-shaped end of the Rhone glacier (No. 1) attained its greatest height, swelled in size and pressed on as it was by others that descended from the north snow-shed of the mountains between the Oldenhorn and the great snow-field above Grindelwald. According to estimates based on the highest ice-stranded boulders, the ice rose 2203 feet above the present surface of the lake. The lake is now 1427 feet above the sea, and 480 feet deep; and the Lake of Bienne is 1425 feet above the sea, and 231 feet in depth. The bottom of the Lake of Neuchâtel is thus 947 feet above the sea. Unless the gravel, therefore, on the banks of the Aar, immediately east of the latter, be over 480 feet deep, the hollow of the lake near its immediate bounds is a true rock-basin; for on the north, south, and west it is surrounded by solid Secondary and Miocene rocks. Even if the rock does not rise close to the surface in the river near the lake, still, at Solothurn, strata in place come close to the river-bank on both sides, the river being 1414 feet above the sea. Under any circumstances there must therefore be a long, deep trough between Solothurn and the rocks a little south-west of the Lake of Neuchâtel. How was this basin formed? When the glacier, debouching from the valley of the Rhone, spread out like a fan and pressed forward till it abutted on the Jura, its onward progress was stopped by that mountain; and direct further advance being hindered, the ice spread north-east and south-west, to the

*The Lake of Geneva is 197 feet lower than the Lake of Neuchâtel. The glacier first surmounted the hills between Lausanne and Vevay, and then flowed down the general slope northwards to the Jura.

†This diagram is on a true scale both horizontally and vertically.

right and left, and being as a whole thickest and heaviest above the area where the lake now lies, a greater quantity of the Miocene strata on which it rested must have been ploughed out there than further on towards the north-east and south-west ends of the glacier, towards which the ice, gradually declining in thickness, exercised less grinding power. In this manner I believe the troughs were formed in which lie the three lakes near Neuchâtel; and when the ice finally retreated, the ordinary drainage of the country filled them with water, the cliffs on the south-eastern side of the Lake of Neuchâtel and other changes of the form of the ground having since been produced or modified by watery erosion and the local deposition of silt and alluvial gravel.

The Lake of Thun.—The Lake of Thun is 1825 feet above the sea, and 776 feet deep. Its bottom is therefore 1049 feet above the sea. It is about 10 miles in length, 1 1-2 broad, and its length chiefly cuts across the strike of rocks of Secondary and Miocene age. The Lake of Brienz (about the same size) is more remarkable; for, while its level is 1850 feet above the sea, its depth is more than 2000 feet: so that its bottom is at least between 100 and 200 feet below the level of the sea. Before the formation of the alluvial plain between, these two lakes were probably united; and whether or not this was the case, it is evident, from its great depth, that the Lake of Brienz lies in a true rock-basin. Even if below Thun the rocks do not crop nearer than Solothurn, the Lake of Thun still lies in a rocky hollow more than 600 feet deep, both hollows having, I believe, been deepened by the great old glacier of the Aar (No. 2 in the Map), the ice of which was so thick that above Brienz it overflowed into the valley of Sarnen by the Brunig, about 1460 feet above the Aar below Meyringen, and sent off a branch which scooped out the hollows of the Lakes of Lungern and of Sarnen on its course towards Alpnach on the Lake of Lucerne.

The Lake of Zug.—The Lake of Zug is about 9 miles long, from 1 to 2 1-2 wide, 1361 feet above the sea, and 1279 feet deep; and its bottom is therefore only 82 feet above the sea. The whole is surrounded by Miocene strata, the strike of which the lake cuts across, and its great depth clearly shows that it lies in a rock-basin.

The Lake of Lucerne.—The Lake of the Four Cantons (Lucerne) ramifies among the mountains and extends its arms in various directions. In its lower part, the branches that run N.E. to Kussnach and S.W. towards Gestad lie partly in the strike of the Miocene and older strata; but for the most part it runs across the average strike of the Eocene and Secondary rocks, between banks, sometimes precipitous, that rise in noble cliffs sometimes more than 2000 feet above the water. Its height is 1428 feet above the sea, and its recorded depth 853 feet; but the shape of the banks and the round number of 800 French feet make it likely that it may contain deeper gulfs than have yet been plumbed. If not, then its bottom is 575 feet above the sea; and those acquainted with the shape of the ground by Lucerne will easily be convinced that the lake lies in an actual rock-basin. The steepness of the walls of this lake more resembles the sides of a rent than those of any of the basins yet described, and the re-entering angles of rock opposite curving bays have been cited as evidences of fracture, one side being supposed to fit into the other. But in most cliffy valleys of aqueous erosion there are necessarily such re-entering angles, from the common action of running water; and, in Switzerland, ere these valleys were filled with ice, they existed in some shape, and were drained by rivers that deepened them and gave them a general form preparatory to the flow of the ice that largely modified their outlines. I should no more consider the re-entering angles a sign of gaping fracture in these valleys than I would the bends of the Welsh valleys or of the tortuous Moselle. But even if at first sight one were inclined to believe the space between the opposite cliffs between Brunnen and Flühlen to be an open fracture, if we take a moderate average slope for each side, say of 65°, and produce it below the water, we get a depth, ere the lines meet, of between 7000 and 8000 feet—a very improbable depth for the original hollow of the lake. But it may be said that the fracture has been much widened by degradation, the line of the break merely giving a line of weakness, along which the surface-drainage might widen the valley. If, however, we only take an angle for the sides of the lake giving a moderate depth, the necessity for a fracture does not exist, and we recur to some process of mere erosion for the scooping of the hollow in which the water lies, that process having, I consider, been the long-continued grinding of the ice of the great glacier No. 3 of the Map.

The Lake of Zurich.—The Lake of Zurich runs from N.W. to S.E., across the average strike of the Miocene strata, which are much disturbed towards its eastern end. It is bounded by high hills, much scarred by the weather, on which the different Miocene strata often stand out in successive horizontal steps. The Linth Canal and the Wallen See lie in an eastern prolongation of this valley, which is still further extended to the valley of the Upper Rhine at Sargans. The lake is about 25 English miles in length, by 2 1-4 wide in its broadest part. A great moraine partly dams it up at its outflow at Zurich; and a second forms the shallow at Rapperswyl, where the lake is crossed by a long wooden bridge. The general level of the water is 1341 feet above the sea, and only about 639 deep; and the bottom of the lake is therefore 702 feet above the sea. The limestone rocks at Baden, on the Limat, are 1226 feet above the sea; and the lake therefore lies in a true rock-basin, though it is probable that the old moraine at Zurich accounts for the retention of the water of the lake at its precise level. The long hollow was in old times entirely filled by the great glacier (No. 4 in the Map, Pl. VIII.) which descended from the mountains between the Todi and the Trinserhorn, through the valley of the Linth, to Baden.

The Wallen See.—The Wallen See lies in a deep valley, whose cliffy slopes of Secondary rocks rise from 2000 to 3000 feet, and in the Leistkamm 4500 feet above the surface of the lake. The lake itself is 1391 feet above the sea; and from the great steepness of its banks it may be inferred that it is exceedingly deep, but none of the authorities I have consulted give its soundings. A large branch from the great Rhine glacier (No. 5 on the Map) joined that of the valley of Glarus and Zurich through this wide gorge, and ground out the hollow of the Wallen See.

The Lake of Constance.—The Lake of Constance, the largest sheet of water in Switzerland, is about 50 miles in length, by about 15 in breadth at its broadest part. It is entirely surrounded by Miocene strata, often considerably disturbed, and forming great hills towards the S.E., which in a remarkable manner evince all the signs of long-continued erosion by running water,—conveying the impression that chiefly by that means all the deep valleys of the district have been worn since the close of the Miocene epoch. This lake lies 1298 feet above the sea; and, its depth being 912 feet, its bottom is only 386 feet above the sea. The falls of the Rhine are 1247 feet above the sea; and the lake therefore lies in an unmistakeable rock-basin, the whole of which was once overflowed by the deep and broad-spreading glacier of the Upper Rhine valleys (No. 5 of the Map), which stretched far northward beyond the lake into Baden and Wurtemberg. Being of greatest thickness where it entered the region of the lake, by its enormous weight and grinding power it scooped out, in the soft rocks below, the wide hollow now filled with water.

The Italian Lakes.—If we now turn to the Italian side of the Alps, we shall find the same phenomena prevailing in the Lakes of Maggiore, Lugano, and Como, the only important lakes I have yet had an opportunity of seeing south of the great chain. To each of these the same reasoning applies, modified only in detail; and I shall therefore briefly pass them over.

The most westerly, the Lago Maggiore, lies in a winding valley, 40 miles long, excavated in gneissic and jurassic rocks, which rise on either side in lofty mountains. The surface of the lake is 685 feet above the level of the sea, and near the Borromean Islands it has the enormous depth of 2625 feet; so that its bottom is 1940 feet lower than the sea-level. It must, therefore, be enclosed all round by rocks, unless we suppose the narrow passage at Arona, near its outlet, to be as deep as its deepest part, or that the alluvial deposits of the Ticino and the Po are more than 1940 feet deep—an assumption no one is likely to make.

Of all the Alpine lakes, that of Lugano is the most irregular in form,—in the language of M. Desor, stretching its arms like a great polyp among the mountains in all directions.* Its surface is 938 feet above the level of the sea, and its depth 515 feet. Its bottom is therefore only 410 feet above the sea-level, and the shape of the surrounding ground renders it impossible to believe that it is not entirely surrounded by rocks.

The Lake of Como, the hollow of which has been scooped out generally in the same set of rocks as the other two lakes, is 700 feet above the sea, and 1929 feet deep; and its bottom is therefore 1229 feet below the level of the sea. On the borders of these lakes the rounded rocks and the well-known glacier-stranded boulders, high on the mountain-sides, attest that these deep valleys were filled to the brim by a vast system of glaciers (Nos. 6 and 7 of the Map,) that flowed southerly from the snow-shed that runs from the eastern side of Monte Rosa, by the Rheinwald-horn, to the top of the valley of the Adda,—a system of glaciers so large that, like that of Aosta and Ivrea (No. 8 of the Map), further west, they protruded their ends and deposited their moraines far south on the plains of Piedmont and Lombardy.

The glacier of Ivrea (No. 8 on the Map), when it escaped from the valley of the Doire, deposited a moraine at its side, east of the town of Ivrea, rising in mere *débris* 1500 feet above the plain, and spreading out eastward in a succession of fan-shaped ridges miles in width. The vastness of this mass gives a fair idea of the huge size of the glacier, and of the great length of time it must have endured; and just as this glacier hollowed out the little rock-basins in which lie the tarns that nestle among the large *roches moutonnées* between the town and the moraine,† so, deep as the hollows of the great Lakes of Maggiore and Como are, I believe they also were scooped out by the grinding power of long-enduring ice, where, under favorable circumstances, the glaciers were confined between the mountains, and therefore thicker than the glacier of Ivrea where it debouched on the plain. Diagrams illustrative of this subject should be drawn on a true scale; otherwise, height, depth, and steepness being exaggerated, the argument becomes vitiated. I have not the data for giving an actual outline of the bottom of the

*See memoirs "De la Physionomie des Lacs Suisses" (extrait de la "Revue Suisse," 1860) and "Quelques Considérations sur la Classification des Lacs, à propos des bassins du revers méridional des Alpes,' by E. Desor. The opinions of M. Desor and my own do not agree on the question of the origin of the lake-basins of the Alps. His views are well expounded in the above-named memoirs. It was in conversation with my friend, in 1860, that I first proposed what I consider the true solution of the question, and to this conversation I presume he alludes in the latter memoir, p. 13,—"On a prétendu que les lacs étaient l'effet de l'affouillement des glaciers qui auraient labouré le sol sur lequel ils s'avançaient," &c.

†There are other well-known lakes dammed up by the moraine of this great glacier.

Lago Maggiore; but a line drawn from the upper end of the lake to the required depth near the Borromean Islands gives *an angle only of about* 3° *in a distance of about* 25 *miles,* and from thence to the lower end of the lake (12 or 13 miles) *of about* 5°. The depths of Maggiore and Como do not, in my opinion, militate against my view; for, if the theory be true, depth is a mere indicator of time and vertical pressure in a narrow space. It is interesting, and confirmatory of this view, that the deepest part of the Lago Maggiore is just at the point where the enormous glacier of the Val d'Ossola joined the great ice-stream that was formed by the united glacier-drainage of the valleys above Bellinzona and Locarno. Where these glaciers united, there the lake begins; and where the ice was on the largest scale near the Borromean Islands, there the lake is deepest.

Summary with regard to the Alpine Lakes.—And now, in reviewing the subject of the origin of the lakes of Switzerland and North Italy, I would remark—

1st. That each of the great lakes (see Map) lies in an area once covered by a vast glacier. There is, therefore, a connection between them which can scarcely be accidental.

2nd. I think the theory of an area of *special subsidence* for each lake untenable, seeing no more proof for it in the case of the larger lakes than for the hundreds of tarns in perfect rock-basins common to all glacier-countries, present or past, and the connection of which with diminished or vanished glaciers I proved originally in "The Old Glaciers of North Wales." In the Alps there is a gradation in size between the small mountain-tarns and the larger lakes.

3rd. None of them lie in lines of *gaping fracture.* If old fractures ran in the lines of the lakes or of other valleys, and gave a tendency to lines of drainage, they are nevertheless, in the deep-seated strata, exposed to us as close fractures now, and the valleys are valleys of erosion and true denudation.

4th. They are none of them in simple synclinal basins, formed by the mere disturbance of the strata after the close of the Miocene epoch: nor,

5th. Do they lie in hollows of common watery erosion; for running water and the still water of deep lakes can neither of them excavate profound basin-shaped hollows. So deeply did Playfair, the exponent of the Huttonian theory, feel this truth, that he was fain to liken the Lake of Geneva to the petty pools on the New Red Marl of Cheshire, and to suppose that the hollow of the lake had been formed by the dissolution and escape of salts contained in the strata below.

6th. But one other agency remains—that of ice, which, from the vast size of the glaciers, we are certain must have exercised a powerful erosive agency. It required a solid body, grinding steadily and powerfully in direct and heavy contact with and across the rocks, to scoop out deep hollows, the situations of which might either be determined by unequal hardness of the rocks, by extra weight of ice in special places, or by accidental circumstances, the clue to which is lost, from our inability perfectly to reconstruct the original forms of the glaciers.

7th. It thus follows that, valleys having existed giving a direction to the flow of the glaciers ere they protruded on the low country between the Alps and the Jura, these valleys and parts of the plain, by the weight and grinding power of ice in motion, were modified in form, part of that modification consisting in the excavation of the lake-basins under review.

In connection with this point, it is worthy of remark that glaciers, many of them very large in the modern sense of the term, on the south side of the Vallais (excepting those of Mont Blanc), and the large glaciers on the south side of the Oberland, all drain into the Lake of Geneva; those on the north of the last-named snowfield, also large glaciers, are drained through the Lakes of Brienz and Thun. These, among the largest existing glaciers of the Alps, are only the shrunken tributaries of the greater glaciers that in old times filled and scooped out the basins of the lakes. The rest of the lakes, as already stated, are in equally close connection with the old snow-drainage of glacier-regions on the grandest scale,—all of them, excepting those of Neuchâtel, Bienne, and Morat, lying in the direct course of glaciers filling valleys that extend right into the heart of the mountains.

8th. Most of the lakes are broad or deep according to the size of the glaciers that flowed through the valleys in which they lie, this general result being modified according to the nature of the rock and the form of the ground over which the glacier passed. Thus, the long and broad Lake of Geneva, scooped in the Miocene lowlands, is 984 feet deep, and over its area once spread the broad glacier of the Rhone. Its great breadth and its depth evince the size of the glacier that overflowed its hollow. The Lake of Constance, lying in the same strata, and equally large, is 935 feet deep, and was overspread by the equally magnificent glacier of the Upper Rhine. The Lakes of Maggiore and Como, deepest of all, lie in the narrow valleys of the harder Secondary rocks of the older Alps; and the bottom of the first is 1992 feet, and the latter 1043 feet, below the sea-level. Both of these lie within the bounds of that prodigious system of glaciers that descended from the east side of the Pennine Alps and the great ranges north and south of the Val Tellina, and shed their moraines in the plains of Piedmont and Lombardy. The depth of the lakes corresponds to the vast size and vertical pressure of the glaciers. The circumstance that these lakes are deeper than the level of the sea does not affect the question, for we know nothing about the absolute height of the land during the Glacial period.

The Lakes of Thun and Brienz form part of one great hollow, more than 2000 feet deep in its eastern part, or nearly 300 feet below the level of the sea. They lie in the course of the ancient glacier of the Aar, the top of which, as *roches moutonnées* and striations show, rose to the very crests of the mountains between Meyringen and the Grimsel.

The Lake of the Four Cantons is imperfectly estimated at only 884 feet in depth; but here we must also take into account the great height and steep inclines of the mountains at its sides. The Lake of Zug, 1311 feet deep, lies in the course of the same great glacier, the gathering-grounds of which were the slopes that bound the tributaries of the Upper Reuss and the immense amphitheatre of the Urseren Thal, bounded by the Kroutlet, the Sustenhorn, the Galenstock, the St. Gothard, and the southern flanks of the Scheerhorn.

The lesser depths (660 feet) of the Lake of Zurich were hollowed by the smaller but still large glacier that descended the valley of the Linth.

This completes the evidence.

Lakes of the Northern Hemisphere generally.—I shall now make a few remarks on the bearing of this subject on the glacial question generally.

It is remarkable that in Europe and North America, *going northward*, lakes become so exceedingly numerous, that I have been led to suppose the existence of some intimate connection between their numbers and the northern latitudes in which they occur.

Let any one examine the map of North America, and he will find that, from the Atlantic coast to the St. Lawrence, through New Hampshire, Vermont, the north of the State of New York, Maine, Nova Scotia, New Brunswick, Gaspé, and Newfoundland, the whole continent is strewn with lakes. North of the St. Lawrence and the great lakes, as far as the Arctic Ocean, the same sprinkling of unnumbered lakes over the entire face of the country is even more remarkable; and it is a curious circumstance that a large part of this vast area is so low and undulating, that some of its lakes drain two ways—towards the North Sea and the Gulf of Mexico, or towards the North Sea and the North Atlantic. This vast country, about as far south as lat. 40°, shows, almost universally, marked signs of the strongest glacial action, in the *moutonnée* forms, polish, and constantly recurring striation of the rocks. I have only seen a few of the above-mentioned lakes south of Lake Ontario; but I have closely questioned that able observer, Dr. Hector, who has examined the country north and west of the great American lakes, and he informs me that, though unable to account for it, he was struck with the circumstance that so many (he thought he might say *all*) of the smaller lakes are in *rock-basins*. I connect this circumstance with the universal glaciation of the country, still evinced on the grandest possible scale by every sign of ancient ice. These signs, I now believe, are far too universal and unvarying in their general directions to have been produced merely by floating ice, though in part of the glacial history of the continent floating ice has undoubtedly left large traces. But the lake-basins could only, I believe, have been scooped out by true continental glacier-ice, like that of Greenland; for the lakes are universal in all the ice-worn region.*

On the eastern side of the Atlantic, Wales, Cumberland, many parts of Ireland, the North Highlands, and some of the Western Isles are also dotted with unnumbered lakes and tarns. All of these are well-glaciated countries, both high and low; and for Wales and many parts of Scotland, I can answer that by far the greater proportion of these lakes lie in rock-basins of truly glacial origin.†

Loch Lomond and Loch Katrine, probably, like the greater lakes of Switzerland, are of the same kind, being merely large cases of glacier-erosion, though in the case of the former it may be that the alluvial deposits on the banks of the Leven prevent its being invaded by the tide. Its islands are mere *roches moutonnées*.‡

In the lowlands of Scotland numerous examples of the same kind of rock-basins occur, some of them certain, others doubtful because of the surrounding drift, which indeed in some cases may be the sole cause of the retention of the water. Notable examples of both kinds occur in the lowlands of Fife and Kinross, and of true rock-basins in the Cleish and Ochil Hills, as for instance Loch Glow, Dow Loch, and the two Black Lochs, and more doubtfully Loch Lindores.

I have not yet had an opportunity of visiting the Scandinavian

*Since this memoir was written, I have conversed on the subject with Sir Wm. Logan, Director of the Geological Survey of Canada, who not only agrees in my views with respect to the origin of American lakes in general, but also believes that the great American lake-basins may have been scooped out by the same means. They are all true rock-basins, in areas occupied by comparatively soft rocks surrounded by harder strata. Given sufficient time, I see no difficulty in this view, to which I inclined while writing this paper, but refrained from stating it, considering that most readers would think it too strong, and thus that in general opinion I might damage the whole theory. Sir William says that the arrangement of the strata proves that the great lakes do not lie in areas of special subsidence.

†See "The Old Glaciers of North Wales." When I published my account of these glaciers, I was too timid to include the Lakes of Llanberis, Llyn Ogwen, Llyn Cwellyn, and some others of the larger lakes in this category. I now feel convinced that they are true rock-basins, and also that the shallower pools of Llyn Llegeirin, Llyn Felin-y-nant, and others in Anglesea had the same origin. The horizontal striations far up the side of Carnedd Dafydd, by Llyn Ogwen, were probably made by a glacier of immense thickness during the first great glacier-period, preceding the deposition of the stratified drift.

‡When the lake was low, I have seen in Loch Lomond ice-striated surfaces of rock just above the water, the striations running in the direction of the length of the lake.

peninsula, which, geologists are aware, is, through all its length and breadth, one of the most wonderfully glaciated countries in the world. On the west, descending from the great chain, striated *roches moutonnées* plunge right under the deep fiords; and on the east, in Sweden, all between the mountains and the Baltic, round the Gulfs of Bothnia and Finland, and up to the North Sea, the whole country is covered with a prodigious number of lakes, just like North America, the Lewes, and the North Highlands of Scotland. The intense glaciation which all of these countries have undergone, their similarity, and what I believe to be the intimate connection of such crowded lakes with the movement of ice, induce me to believe that in Sweden also a great number of the lake-hollows must be true rock-basins scooped out by the passage of glacier-ice into the Baltic area. Furthermore, as the glaciated sides and bottoms of the Norwegian fiords and of the saltwater lochs of Scotland seem to prove, each of these arms of the sea is merely the prolongation of a valley down which a glacier flowed, and was itself filled with a glacier; for the whole country was evidently, like the north of Greenland, moulded by ice. In parts of Scotland, some of these lochs being deeper in places than the neighboring open sea, I incline to attribute this depth to the grinding power of the ice that of old flowed down the valleys, when possibly the land may have been higher than at present.* It may, however, only arise from unequal deposition of detritus. If the former view be admitted, raise the land so as to lay bare the surrounding ocean-bottom, and in some respects of levels and depth they become approximately the counterparts of the deeper narrow lakes of Switzerland and North Italy, glaciers bounded by mountains having flowed through both, and debouched upon the plains beyond.

The Glacial Theory.—Furthermore, considering the vast areas over which the phenomena described are common in North America and Europe, I believe that this theory of the origin of lake-rock-basins is an important point, in addition to previous knowledge, towards the solution of the glacial theory; for I do not see that these hollows can in any way be accounted for by the hypothesis that they were scooped by floating ice.† An iceberg that could float over the margin of a deep hollow would not touch the deeper recesses of the bottom. I am therefore constrained to return, at least in part, to the theory many years ago strongly advocated by Agassiz, that, in the period of extremest cold of the Glacial epoch, great part of North America, the north of the Continent of Europe, great part of Britain,

*But this is not essential, unless the lochs are so deep that the ice must have been floated up before reaching the deeper parts.

†I do not in any way wish to deny that much of the glaciation of the lower countries that came within the limits of the Drift was effected by floating ice on a large scale, which must have both polished and striated the rocks along which it ground. I have, with other authors, described this in various memoirs. But the two sets of phenomena are distinct.

Ireland, and the Western Isles,* were covered by sheets of true glacier-ice in motion, which moulded the whole surface of the country, and in favorable places scooped out depressions that subsequently became lakes.

This was effected by the great original glaciers (probably connected with the origin of the *unstratified* boulder-clay) referred to in my memoir on the glaciers of North Wales,† but the magnitude of which I did not then sufficiently estimate. The cold, however, continued during the depression of North Wales and other districts beneath the sea, when they received the *stratified* erratic drift; and glaciers not only did not cease at this time of depression, but were again enlarged during the emergence of North Wales and other countries, so as to plough the drift out of many valleys. These enlarged glaciers, however, bore no comparison in size to the great original sheets of ice that converted the North of Europe and America into a country like North Greenland. The newer development of glaciers was strictly local. Amelioration of climate had already far advanced, and probably the gigantic glaciers of Old Switzerland were shrinking into the mountain-valleys.

Finally, if this be true, I find it difficult to believe that the change of climate that put an end to this could be brought about by mere changes of physical geography.‡ The change is too large and too universal, having extended alike over the lowlands of the Northern and the Southern Hemispheres. The shrunken or vanished ice of mountain-ranges is indeed equally characteristic of the Himalaya, the Lebanon, the Alps, the Scandinavian chain, the great chains of North and South America, and of other minor ranges and clusters of mountains like those of Britain and Ireland, the Black Forest, and the Vosges.

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* The Lewes is covered by small lakes.

† Quart. Journ. Geol. Soc. vol. xviii. p. 371.

‡ It has been suggested to me by Dr. Sibson that the prodigious waste of the Alps by the gradual disintegration and diminution of the upper snow-fields, witnessed by the great moraines of North Italy and other phenomena, must have tended to lessen the glaciers. This is true, but as he also believes, it is not of itself enough to account for the shrinking of the ice into the higher valleys where it is now alone found.

II.

ON THE FORMATION OF ALPINE VALLEYS AND ALPINE LAKES. BY JOHN BALL, M.R.I.A., F.L.S., &c.

EVERY one who feels an interest in the past history of the Alps must be glad to find renewed attention given to the natural agencies that have given that region its existing conformation. Many persons will therefore have read with satisfaction the papers recently published by Professor Ramsay, the President of the Geological Society, in the Quarterly Journal of that Society for August 1862, and by Professor Tyndall in the Philosophical Magazine for the following month. To these should, perhaps, be added some important observations contained in an address delivered at the recent Meeting of the British Association, by Mr. Beete Jukes, the President of the Geological Section. In these publications by eminent English men of science, the views of preceding alpine geologists, such as Charles Martins, Gastaldi, and Omboni, which have been ably summed up and extended in some recent memoirs by M. Mortillet, have received a still wider extension, and we are called upon to enlarge very much our previous conceptions as to the agency of those great glaciers which, at a period geologically very recent, descended from the flanks of the higher Alps to the level of the plains.

If controversies in science were decided by the authority of eminent names, or if the discussion of the problems raised by these papers required a complete acquaintance with the whole field of physics and geology, I should certainly not enter the lists against such formidable opponents. The problems in question, however, occupy a limited field in the region which is common alike to physics and to geology; their solution depends in a great part upon facts which must be studied on the ground; and I am thus led to hope that a somewhat long and extensive acquaintance with the Alps, during which the questions at issue have been very frequently the subject of my thoughts, may authorize me without presumption to take a share in the discussion. Writing at a distance from England, and with but slight opportunities for knowing what is passing elsewhere, I shall be forgiven if I repeat objections previously urged by others, or advance arguments that have been already satisfactorily answered.

Professor Ramsay attributes to the action of glacier-ice the hollowing out of lake-basins in the Alps and elsewhere; Professor Tyndall sees in the same powerful agent the main, if not the exclusive, means for the formation of alpine valleys. An anonymous writer, in terms which show that his knowledge of the subject is on a par with his good taste, has confounded together the scope of the two papers. I hope to show not only that the problems attempted to be solved by their writers are different, but, furthermore, that the main objections to each solution rest upon considerations entirely distinct.

Taking, in the first instance, the larger of the two questions raised for discussion, I shall inquire whether there is reason to admit Professor Tyndall's conclusion, drawn chiefly from his observations in the neighborhood of Monte Rosa, that the valleys of the Alps have, as a general rule, been scooped out by great glaciers from the flanks of previously continuous mountain masses.

The first thought of any one considering this question is to endeavor to take a comprehensive view of the present configuration of the surface. If the reader will look at any general map of the Swiss and Savoy Alps, he will in the first place observe that between the higher central ranges and the plains of France there is interposed a zone of secondary rocks, elevated into ridges from 4000 to 6000 feet above the sea-level. In carrying his eye along this zone from the neighborhood of Grenoble to that of Aarau, he will see that the direction of the ridges, which is at first nearly north and south, is gradually bent towards the east, so that the principal chain of the Jura points from N.E. by E. to S.W. by W. He will further observe that the chain nowhere consists of a single ridge, but of three, four, or five parallel ridges with furrow-like valleys lying between them, here and there cut through by some stream that appears to flow through a fracture that has traversed the entire range. Including along with the Jura the ranges of Western Dauphiné, the Vosges Mountains, and the somewhat higher ridges west of the valley of the Arty, it will be apparent that the arguments of Professor Tyndall cannot possibly apply to a system of valleys which are, without exception, parallel to the highest ridges, and where, if the present inequalities were filled up, and the whole mass covered with ice, the new glaciers, supposing them competent to form valleys, would certainly shape them at right angles to their present direction.

If he neglect these outlying ranges for a moment, and direct his attention to the central region of the Alps, the observer will scarcely fail to note, as one of the most characteristic features of the Swiss Alps, the line of valley which extends for nearly 140 miles from Martigny to Coire. With one slight distortion, the Rhone flows directly from E.N.E. to W.S.W. between the Furka Pass and Martigny. On the opposite side of that low pass, the line of valley descending to Andermatt preserves exactly the same direction. The famous gorge of the Devil's Bridge allows the Reuss to carry off towards the north the drainage of the valley, but the main line of depression keeps true to its original direction through the glen that mounts to the Oberalp Pass; and east of that ridge the same direction is so accurately preserved, that a line drawn from Chiamot (the highest hamlet) to Coire is nowhere half a mile from the present bed of the Vorder Rhine. Another of the main valleys of the Alps, that of the Inn, is nearly exactly parallel to the standard line which we have traced across Switzerland. From Kufstein, where the railway enters the Tyrol, the valley of the Inn, with a slight distortion between Innsbruck and Ried, maintains a constant direction up to its head at the lake of Sils; but a traveller following steadily the same course finds the pass of the Maloja west of the lake very little raised above the level of the valleys on either side, and leading through the Val Bregaglia to Chiavenna, from whence, if he will keep on W.S.W. across the ridge that separates him from Roveredo, he will enter another line of valley that is continuous with the upper end of the Lago Maggiore, and may even be traced through the Val Vegezzo and the Val Anzasca to the foot of Monte Rosa. It is sufficient to carry the eye across the map, to perceive how very generally the same direction prevails among the valleys of the central region of the Alps, and that, as in the instances above quoted, these lines of depression traverse a ridge, or contain streams that flow in opposite directions—showing that by no conceivable change in the general conformation of the land could a single stream or glacier have done the work. The line of valley, in great part occupied by lakes, that stretches from Interlaken to Kussnach on the Lake of Lucerne, the system of valleys between the Lake of Thun and the Rhone, the Val Pellina, the Lex Blanche or Allée Blanche, and the Valley of Chamouni, are so many instances in point, and, when taken together, bring to my mind the conviction that some considerable portion at least of the existing valleys in the Alps owe their origin to forces which have operated on a great scale, and which can scarcely be any other than those that have raised the mountain ridges to which the same valleys are related. If it be urged that several of the valleys to which I have referred lie along the line of outcrop of softer and more easily disintegrated rocks, such as certain slates in the valley of the Rhone, and that the action of either water or ice would for that reason be more effective in scooping out the valley where we now see it, I may reply that the very fact alleged shows the working of denudation along the same line at some early period in the history of the elevation of the Alps, and the strong probability of the existence at the same period of a corresponding valley.

If we now pass from the contemplation of a wide tract of mountain country to the examination of particular groups or *massifs*, we very frequently find indications of the prevalence of a common direction in the secondary ridges and valleys, transverse, but seldom exactly perpendicular, to that of the main valleys. Thus in the Bernese and Lepontine Alps we find the ridges enclosing the two main branches of the Aar Glacier, those on either side of the Geren Thal, the Val Leventino between Airolo and Faido, and several minor valleys, all showing a degree of parallelism which points to the operation of some common cause. The series of seven minor valleys lying about due east and west between the Val Maggia and that of the Tosa is perhaps a better illustration, as there is nothing in the general configuration of the district to make it conceivable that, if the hollows were filled up, water or ice would reopen trenches where the present valleys exist. The four or five great ridges extending northwards from the range of Monte Rosa towards the valley of the Rhone furnish, as I believe, another illustration of the same tendency to the formation of groups of parallel valleys.

The facts hitherto adduced seem to me to point very strongly to the conclusion that mechanical forces, acting on a large scale and in definite directions, have had at the least a considerable share in the formation of alpine valleys. For reasons to which I shall further advert, it appears most probable that complicated forces acting on the mountain masses have given rise to many valleys whose direction gives no clue, or none that has yet been traced, to their origin ; but I am quite ready to admit that the present condition of the surface cannot readily be explained without very largely admitting the action of water, whether in the liquid or solid form. To study the various agencies that, sometimes working together, sometimes in alternation, have given to the alpine world its present form and aspect, to attribute to each its own share, and to find fair evidence in support of his conclusions, is the formidably difficult task of the alpine geologist; and even if he be fortunate enough to gain the help of the ablest workers in the field of physical science, it will be long before that task can approach to a conclusion. In considering whether or no it is probable that the agent which has excavated valleys whose vertical depth below the ridges that enclose them often exceeds an English mile, and in two of the valleys referred to by Professor Tyndall is at least a mile and a half, the first step is to examine the mode of action of existing glaciers.

The whole mechanical effect of a glacier upon its bed is directed towards the removal of inequalities, whether in the bottom or sides. It is quite understating the case, to say that if valleys were excavated by ice through strata at all approaching to uniform hardness, they would all tend to the same type of equal slope in the bed, and absence of projecting masses in the containing walls, of which the valley of the Rhone between Martigny and Sion gives the best known example. Any one who has watched the manner in which the bottom of a glacier slides over the concavities without touching them, and applies all its immense grinding power to the convex portions of its bed, will admit that a great degree of inequality in the resistance of different portions of the rock would not prevent a valley scooped out exclusively by glacier-action from approaching nearly to the same uniform model. Fortunately for the lover of natural scenery, the fact is widely different from what it would be if the theory were generally well founded. The most common type of an alpine valley is that which is formed by a succession of level basins rising in steps one above the other as they approach the head of the valley, and connected by gorges whose opposite sides often approach near together, and which are always much narrower than the basins that they link together. There is often distinct evidence, and usually good reason to suspect, that these basins were originally lakes; and in the walls of the gorges intermediate it is common to see proof that at some former period the depth of these lakes must have been greatly increased by barriers of rock, that once held them in and at a later period were cut through by streams of ice or water. I do not pretend that the type of valley above described is universal; but it is too common, both in the Alps and other mountain countries, not to present a formidable difficulty in the way of Professor Tyndall's bold hypothesis. Even though I should admit, as I cannot do, that such lakes as still exist, or have existed, could be formed by a glacier, the existence of a succession of such approximately level steps, separated by steep slopes and narrow gorges, is to me a conclusive proof that some agency other than that of ice must have directed the original formation of valleys of this type. In one respect the inequalities of the sides of alpine valleys offer a stronger argument against their glacial origin than those of their bed. The surface of the ice, even near the side of the glacier, moves much faster than the part in contact with its bed; and it suffices to cut away the foundation of a lofty cliff at the point where the glacier abuts against its base, to determine its fall. Looking at the operatian as a whole, it is to me quite inconceivable that a glacier should be competent to scoop out valleys a mile or more in depth, and yet be unable to remove the main inequalities from its own channel.

A comparison of the effects of existing glaciers with those of the present torrents must lead many observers besides Professor Tyndall to the conclusion that the former are far more powerful excavators than the latter, but do not to my mind justify the inference that no assignable limit can be placed to the work which they have actually accomplished. Vast as the period may be during which glaciers occupied many of the valleys of the Alps, it was not long enough to enable them to accomplish more than a certain definite amount of excavation; and I think it likely that the amount may hereafter be determined with some degree of accuracy. Indications are not wanting both of what glaciers have achieved, and of what they have failed to achieve. Ever since the range of Mont Blanc assumed its present form, before the so-called glacial epoch, and during that long period, and ever since down to the present hour, the snow that accumulates in the basin of the Mer de Glace has been discharged into the valley of Chamouni by the ice-fall of the Glacier des Bois. During the whole of that immense period, the uttermost mechanical effect of the glacier upon its bed has been applied to grind down the ledge over which it has to flow, and to bring the channel to a uniform slope. It is impossible to doubt that a considerable effect has been produced; the ledge has been lowered perhaps by 1000 feet, possibly more; the angle which the slope of the ice-fall makes with the glacier above has been rendered much more obtuse; but still the ice-fall remains, and the bed of the glacier has not been ground down to the uniform slope.

I refer to a well-known glacier, familiar to many readers, though I can conceive a partial, but, I think, an insufficient answer to my argument, founded on local conditions, and not on general grounds. I could easily cite many similar instances which would be less open to cavil. The same argument, *mutatis mutandis*, might be applied to lateral obstacles, such as the rocks known as l'Angle on the west side of the same glacier.

It is impossible to leave this part of the subject without some brief reference to the ingenious suggestion of Professor Tyndall, who perceives in the operations of the glaciers upon the rocky framework of the Alps, not merely the agent that has hollowed out the existing valleys, but one competent, by its destructive power, to bring about the change from the present climate of the Alps to that which prevailed when the glaciers descended to the plains. If I could have the pleasure of standing beside him on the Superga, or any other central position from whence he could survey the outline of the main chain of the Cottian and Pennine Alps, serrated with peaks and intervening depressions, I would beg of Professor Tyndall to consider in detail whether, and by what means, glaciers, however extensive, or endowed with whatever mechanical power, could have determined the form of the topmost crest of that great range, or can hereafter reduce it below its present level. It will certainly not escape him that the grinding power of ice is exerted to an appreciable extent only by considerable ice-streams flowing through defined channels, when they have reached the level at which the temperature of the whole mass is brought near to the melting-point, and that the snow and ice which cover the highest parts of the Alps, so far from tending to hasten their downfall, act as a protection from other agents of destruction; so that in truth no rocks, except those at a considerable depth below the surface of the sea, are so little exposed to degradation as the tops of high snowy mountains. Whatever effect glaciers have produced in reducing their own limits, must have been effected, not by lowering the general level of the ridges of the Alps, but by deepening the hollows, and unfitting some portions of the area from serving as reservoirs for the accumulation of snow. Professor Tyndall, if I may venture to say so, has thrown additional light on the recent history of the Alps and other high mountain countries by directing attention to one of the causes that must have contributed to reduce within narrower limits the action of glaciers, but has not gone near to proving that the deepening of the main channels suffices, without other climatal changes, to account for the disappearance of glaciers that formerly reached to the level of the plains of Piedmont and Lombardy, to a distance of 30, 40, and even 80 miles from the limits of the existing ice-streams.

I pass over many facts of secondary importance which seem to me to confirm the views above advocated, merely glancing at one which is familiar to most persons who have studied the working of the ancient glaciers of the Alps—the record, namely, which is preserved by the harder rocks of the former limits of glacier-action. In scanning the rocky sides of the higher alpine valleys, the contrast between the surfaces that have once been subject to the passage of a glacier, and those that were not reached even by the highest level of the ancient ice-flood, has struck every observer. Where the rock is hard enough to resist subsequent degradation, the eye follows the track of the former glacier as easily as it traces high-water mark by the fringe of sea-weed on the shore; and if this mark avails as positive evidence of the former extension of glacier action, it is not less a negative proof that that action did not surpass certain assignable limits.

I shall now offer some brief remarks upon Professor Ramsay's theory of the origin of alpine lakes. Although M. Mortillet had anticipated Professor Ramsay in attributing the formation of the lakes of Lombardy to the action of ancient glaciers, his speculations on the subject are far more guarded, and at the same time fall short of the generality which marks those of the eminent British geologist; it is to the latter, therefore, that I shall in the first place address myself.

Professor Ramsay's argument may be summarily stated in a few words. Each of the great alpine lakes lies in an area once covered by glacier; no satisfactory explanation of the origin of alpine lakes has yet been given; the glacier considered as a mechanical agent is competent to scoop out the rock basins in which the alpine lakes generally lie; therefore, the lakes have been formed by glaciers.

The first of these propositions, even though it be admitted with some reserve, does not hold inversely, as it should do if the scooping out of rock basins were one of the natural functions of glaciers. Why should not the glacier that flowed from Susa to beyond Turin, or the still vaster mass that descended from the Val d'Aosta, excavate a basin as deep and large as the Lago Maggiore or the Lake of Como? Why throughout the Dauphiné Alps, or the far more extensive region of the Tyrolese, Salzburg, Carinthian and Styrian Alps, are no lakes found in the path of the great extinct glaciers? Again, in admitting the proposition in its direct form, it is necessary to draw a marked distinction between the assertion that the existing lakes lie within an *area* once covered by glacier, and the fact that *some of them* lie in valleys which once gave passage to the *main stream* of an extinct glacier. Even though the efficiency of the glacier as an excavating tool were demonstrated, instead of being, as I feel sure, capable of disproof, it is not easy to conceive how it could have been applied to the hollowing out of such basins as the Lake of Lugano or the Lake of Zug. The mountain-valleys that are drained into the former lake are of the most trifling dimensions, and their height relatively insignificant. The main supply of ice to the basin of the lake was, on the one hand, from the glacier of the Adda, then occupying the site of the Lake of Como, across the ridge between Menaggio and Porlezza, and, on the other, from the glacier of the Tessior over the pass of Monte Cenere. The relatively slender streams which flowed over these barriers might suffice under given climatal conditions to fill the lake-basin with ice, which would spread, as really occurred, beyond its present limits; but the result must have been to produce an ice lake rather than an ice river; and the boldest speculator in glacial theories must hesitate to assert that any agency was there present that could even tend to excavate a trench which, according to the latest measures, is 919 feet below the present level of the lake.

The difficulty of applying this theory, even if it were otherwise tenable, to such a lake as that of Zug, 1279 feet in depth, or to others that might be cited, need not be discussed in detail. The facts simply show that water, whether in the solid or liquid state, tends, under the action of gravity, to seek the lowest level.

With reference to that part of Professor Ramsay's memoir which tends to clear the way for the admission of glacier-action by denying the validity of other explanations of the origin of lakes, it would be rash in me to enter into controversy with so accomplished a geologist; yet I own to the belief that the causes may be various, and that, until we have acquired more accurate knowledge of the processes by which mountain chains have been uplifted, it is premature to declare ourselves incompetent to explain the depressions of the surface with which the mountain ridges are correlated. In any case we are not entitled to argue from our own ignorance to the admission of a new agent, until its competency shall be proved by direct evidence.

I am thus led to examine the point upon which the new theory really turns, and which, as it seems to me, has been taken for granted rather than cautiously investigated. The assumption, which is common to Professor Ramsay and to M. Mortillet, that the excavating power of a glacier in hollowing out a plain surface, or in deepening an existing basin, is proportioned to the weight of the mass pressing on its bed, seems to me to rest upon a superficial view of the mechanical conditions of glacier-motion. It has long been demonstrated that, even when lying on a slope considerably inclined, the friction of the rocky bed against the under surface of the glacier suffices to retard the motion of the lower portion of the ice-stream so that this bears but a small ratio to the velocity of the upper surface. It is impossible to doubt that this retardation would be increased very largely in the case of a glacier lying upon a level though irregular surface, though, if this were of slight extent, the weight and momentum of the glacier behind might impress upon it some slight progressive movement. But if we suppose a glacier of great thickness to lie on a level surface many miles in extent, it is easy to see that the movement of the lower surface of the ice would be completely stopped, and that the onward movement would be effected by the flowing of the upper over the lower portions of the mass. It is forgotten that the resistance offered by friction would be increased to an almost infinite extent, while the resistance of the substance of the glacier to internal rearrangement is confined within moderate limits. M. Mortillet has estimated that the pressure of the ice upon the bed of certain ancient glaciers occupying lake-basins must have reached 300 and even 500 tons per square metre; but if this pressure were even ten times as great, the effect would only more certainly have been to force the ice of the lower surface into every inequality of the bed, and to make the resistance to onward movement more and more insuperable. When the front of the glacier is supposed to move up a slope, as in Mr. Ramsay's diagram of the Lake of Geneva, the above reasoning applies *à fortiori*. If, on further consideration, Professor Ramsay should feel doubtful on this point, I would urge him to make direct observations, which may tend to satisfy his own mind, and that of others who may naturally be swayed by his authority. It is not easy to find the conditions under which such observations could most usefully be attempted; but the glacier of La Brenva, and some others where the ice impinges against fixed obstacles, may furnish matter of instruction.

It will be obvious to the reader, that the question here discussed has a considerable bearing upon Professor Tyndall's views of the formation of valleys. The reason why the action of a glacier is more limited than appears probable to one who considers the enormous mechanical power developed in its progress, is because the greater part of that power is expended in overcoming the resistance of the mass to internal rearrangement, and a small portion only is applied to the onward motion of its lower surface, by which alone any mechanical effect is produced on the subjacent rocks.

If it should not appear superfluous to discuss at greater length the mechanical question involved in Mr. Ramsay's theory, I might ask how we are to believe that the glacier of the Rhone, after it had flowed out of its native valley, when, being no longer confined within a defined channel, it had covered with ice the plain of Switzerland as far as the Jura, was yet able to excavate a rock basin 50 miles and more in length, 12 miles broad, and nearly 1000 feet deep, while at the point where its mechanical power was at its maximum, in the defile of St. Maurice, it has failed to cut through rocks of no extreme hardness a more spacious opening than that which the traveller still sees between Bex and Martigny. It is a complete under-estimate, to assert that the glacier must have moved through that defile at a pace twenty times greater than its rate of motion anywhere over the level of the lake; yet we see how limited its effect has been upon the containing walls of the valley.

A very interesting paper by M. Mortillet, referred to by Professor Ramsay, but not as generally known as it should be in England, is mainly devoted to prove that the lakes of Lombardy must have at one time been filled up by the post-pleiocene diluvium, which forms so important a deposit throughout the entire valley of the Po, and that they have been cleared out by the glaciers which descended into them during the subsequent glacial epoch. M. Mortillet is careful to admit that against solid rock the glacier would be comparatively inoperative, but he assumes rather than seeks to prove that the case would be different in regard to the incoherent masses of rolled pebbles, sand, &c. which make up the diluvium. M. Mortillet is a shrewd reasoner, and he has made out a good *primâ facie* case for his hypothesis, which does not present such formidable difficulties as that of Professor Ramsay; but I own myself to be sceptical as to the possibility of a glacier under the supposed circumstances excavating, even in yielding materials, trough-like basins which vary in depth from 900 to 2600 feet. I feel convinced that the whole effective work must have been accomplished during the advance of the glacier by the front of the ice, which might probably, to a limited extent, have ploughed out a furrow in soft materials; but from the moment when any portion of the diluvium became covered over by the glacier, the enormous weight of the ice would tend to consolidate it, and, for the reasons already given, the grinding action produced by the advance of the lower surface of the ice over its bed would disappear, or be reduced within very narrow limits.

An additional difficulty, fatal, as I think, to Professor Ramsay's theory, and hard to reconcile with that of M. Mortillet, arises from the presence in most alpine lakes of projecting points of rock, and sometimes of rocky bays and coves facing in the direction towards which the glacier formerly flowed. An instance which may be familiar to some readers is the rocky promontory, extending into the Lake of Como, south of Tremezzo, whereon stands the Villa Arconati. The glacier, whatever its efficacy as a tool may have been, worked in one direction only, and cannot have scooped out hollows in a direction contrary to its own current. Such irregularities as I speak of cannot be accounted for on Professor Ramsay's theory; and according to M. Mortillet we should expect to find them at least partially blocked up by diluvium, remaining *in situ* in those places where it had not lain in the path of the glacier stream.

The vast moraines which circle round the opening of the greater valleys on the southern side of the Alps, and extend beyond the limits of the existing lakes, rest upon diluvium formed of the same materials as the moraines, but extensively water-worn, the pebbles being rounded and usually smaller in size, and the materials partially sifted and imperfectly stratified. The moraines have evidently been left in their present position by the ancient glaciers which filled up for a long period the lake-basins; but before the glaciers had filled these basins, how was the diluvium carried across such long and deep hollows as those occupied by the great Italian lakes? M. Mortillet argues, with apparent justice, that in order to reach the plain it must have first filled up the intervening hollows. The conclusion does not, however, seem to me necessary; and I will venture to suggest two alternatives, either or both of which in succession seem to me more satisfactory.

It is quite certain that during the period when the diluvium was being reduced to its present condition, and was spread out over the valley of the Po and the plain of Friuli, that tract was the bed of a shallow sea; and there is good reason to suspect many oscillations of level between the Miocene period and the last great extension of the glaciers, during which the region in question may have been alternately uplifted and submerged. Geologists who have renounced the doctrines of the cataclysmal school have yet retained much of the language and habits of thought which were there learned. It is still their tendency to speak and think as if the history of the earth were that of a series of great events (revolutionary periods) separated by intervals of repose, rather than a slowly rolling cycle of incessant change wherein the same natural agents, perhaps in altered combinations and with varying intensity, constantly recur. Since the importance of ice as an agent in geological change has been clearly demonstrated, geologists have concentrated their thoughts upon a single period immediately preceding the establishment and actual distribution of the present fauna and flora, and have, in accordance with their habitual tendency, called this *the glacial epoch.* I am of course aware that some geologists have pointed out the traces of glacial action at former geological periods; but it cannot be said that they have generally recognized the reasonable conclusion, that if one of the latest conditions of the earth admitted of a great extension of glacial action, a similar combination of causes must probably have brought about the same effects at many recurring periods.

To my mind there is nothing strange in the supposition that the materials of the diluvium of the valley of the Po were brought down from the upper valleys of the Alps and across the lake-basins by glaciers, and by them shot out as rubbish on the margin of the plain, before the latest invasion of the sea, exactly in the same manner as we know that the still existing moraines were at a later period deposited. If the sea rose before the glaciers retired to the upper valleys, ice-rafts of great dimensions laden with moraine would have floated down the fiord-like inlets, and would have rapidly melted on reaching the open sea. Whenever this did not rise much above the present level of the lakes, it is likely that the materials of the diluvium were accumulated near the lower end of each lake by the stranding of the ice-rafts on the shallow bar. It is even doubtful whether some supposed moraines have not been formed in this manner. In either or both of the two modes here indicated (by a solid causeway of ice, or by floating ice-rafts) I believe that the diluvium, as well as the more recent glacial deposits, have been borne from the central regions of the Alps to the plains of northern Italy; and I am the more persuaded of this because I know of no other means by which so vast a mass of solid materials could have been carried so great a distance. The action of running water has been perhaps underrated of late as a means of cutting a passage through even hard rock; but it is difficult to think too meanly of it as an agent for the transport, on a great scale, of solid fragments over a wide space, such as intervenes berween the St. Gothard and the plain below Arona, or between the Stelvio and Monza, the one distance approaching near to, the other considerably exceeding, 100 miles. Fine sand and finer mud are carried in vast quantities by existing currents ; but even where these appear to bring down rolled specimens of the rocks that surround their sources, it generally turns out that such pebbles are picked out from some ancient ice-borne deposits lying near the banks or in the bed of the stream. The effects evèn of such exceptional events as the well-known flood in the valley of the Drause, the like of which recur at intervals in every part of the Alps, are limited within very moderate limits; and, though the Lake of Geneva were filled up to facilitate the transport, I doubt whether a million of Drause-floods would bear any appreciable amount of diluvium to the site of the city of Geneva.

If this were the proper occasion, there are many observations in M. Mortillet's valuable papers that deserve further discussion, and some of the details in his sketch of the ancient glaciers of northern Italy, to which I should be inclined to except; but I pass these over, and also forbear some remarks which I might offer upon two interesting papers by M. E. Desor, wherein the writer attempts a classification of alpine lakes, which, saving some details, seems to me founded on just views.*

I might here close these remarks, which are directed rather to combat what appears to me excessive in recent theories, than to attempt a complete explanation of the origin of alpine valleys and lakes. Probably the time is not yet come for a solution of the difficulties connected with this great problem; but a writer with no scientific reputation to defend, who has often been led to reflect on the subject in the presence of those great monuments of the past history of the earth that survive in the Alps and in other mountain districts, may throw out for future discussion the result, though confessedly incomplete, of his own efforts to account for the phenomena.

I may mention that my ideas on this subject have been formed in all but utter ignorance of the views of those geologists who have maintained opinions somewhat similar, and in particular of those of Constant Prevost and Dana. I am very imperfectly aware of the progress of speculation even at present in the same direction ; but it seems to me that, while both the writers above-named, and several others, have proceeded in the right track, they have not followed out the fundamental conception with the requisite strictness to its legitimate consequences. That the earth has gradually cooled down from a previous high temperature during the period which has inter-

* He divides the Orographic Basins into: (a) Valley or Trough lakes, parallel to the direction of the mountain ranges: (b) *Combe* or Fault lakes parallel to the range; and *Cluse* or lakes in fissures across the range. See "De la Physionomie des Lacs Suisse" S. E. Desor, in Revue Suisse, 1860. (Ed.)

vened between the earliest geological record and the latest tertiary epoch, and that by a necessary consequence it has diminished in volume during the same period, is the belief of many, probably of nearly all geologists. This hypothesis, duly followed out, leads us towards an explanation of the origin of mountain chains, and the correlated depressions, which, if not quite complete, appears to me far more satisfactory than any other, and readily applicable to the leading points of the orography of the Alps. Those who have speculated on the subject seem to me to have erred in looking to local subsidence as the chief mechanical result of contraction by cooling, and more especially when they have supposed certain areas of the earth's surface to have been, in a special and exceptional sense, areas of cooling.

The postulates which may, as I think, be justly assumed for the purpose of reasoning on the hypothesis in question are these:—

I. From the period when organic life commenced on the surface of our planet, the outer portion of the crust must have assumed a temperature not far removed from that which now possesses, and which depends mainly upon the ratio between the heat received from the sun and that lost by radiation.

2. The inner portion ot the crust, and the nucleus, usually supposed to be viscous or fluid, being cooled with extreme slowness by conduction, would contract much more than the outer surface of the spheroid.

3. The process of cooling would be continuous and uniform, subject only to trifling local variations arising from the unequal accumulation of sedimentary strata over particular areas, and the unequal conductive power of certain portions of the crust.

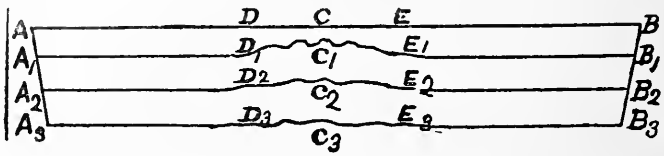
4. No substance is absolutely rigid; and there is no reason to doubt that amorphous masses of mineral matter, such as constitute all rocks, are capable, under adequate force, of a considerable amount of flexure.

5. From a very early period in the earth's history, dating from the first appearance of water on the surface, if not earlier, inequalities in the outer surface, arising from denudation in some areas, and the accumulation of sedimentary strata in others, must have begun to exist, and have been continually extended and varied ever since by the action of the various causes that have brought the crust to its present condition.

It is conceivable, and even probable, that during some considerable period of the earlier history of the earth, the amount of contraction from cooling in successive concentric shells may have continued to be approximately proportional to their distance from the centre of the spheroid, in which case no mechanical forces would be called into play that would tend to alter the form of the outer surface. The conditions were altered from the time when the outer crust, having approached to a constant temperature, ceased to keep pace with the contraction of the interior, and I ask the reader to consider the necessary effects of that change.

To fix our ideas, let us take an area of 500 miles squared, and assume that during a certain period (which would be of enormous length if counted by years) the radius of the earth had contracted through cooling by 1200 yards, equal to about a 6000th part of its own length. Using round numbers, which suffice to illustrate the argument, the result of this change will have been to force the outer crust of the area under consideration to occupy a space less by 150 yards in every direction than before the contraction. If the crust were of uniform rigidity throughout the same area, and also in the adjoining regions, the result must be a general crushing and crumpling of the surface; but we have taken it for a certainty that in reality the condition of things has been otherwise, and that lines of least resistance have existed which must have determined the yielding of the crust in one direction rather than another. Let us assume that in the regions adjoining the given area the preponderating direction in which the crust had already yielded was N. and S., in which case the pressure transverse to that direction will have been diminished, and therefore that, during the given period within the same area, the forces acting on the crust must be mainly lateral forces compressing the mass in the direction of the meridian. To form a more accurate idea of the changes which would result, let us take an imaginary meridional section 500 miles in length, and suppose that the least-resisting part of the crust lies at the centre of the section, the rigidity increasing gradually on either side. As we have already seen, the mechanical effect which will be produced by the action of gravity (assumed to be capable of overcoming the resistance of the mass) will be to force each extremity of the section to approach the centre by 75 yards. The first flexure having occurred at the centre, the ordinary laws of the resistance of imperfectly elastic and imperfectly rigid bodies lead to the formation of parallel ridges with intermediate depressions extending on either side of the first flexure within limits depending on the flexibility and compressibility of the crust. We shall assume the limit at 50 miles on either side of the centre. The annexed figure will give some idea of the nature of the vertical disturbances, the scale being very greatly magnified to make them sensible to the eye, and no attempt being made to exhibit the curvature of the surface.

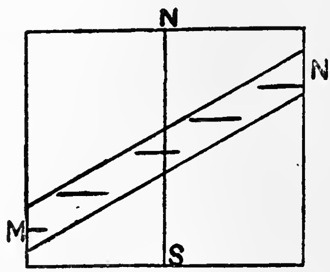
The dotted line A B shows the section of the original surface before the period of disturbance, and A^1 B^1 that after subsidence, with a series of ridges and depressions, highest at the centre C^1, and extending to D^1 and E^1 respectively 50 miles from C^1. No vertical disturbance will have arisen in the portions $A^1 D^1$ and $E^1 B^1$, but a displacement has nevertheless been caused which deserves attention. Having left out of view the changes going on in neighboring areas, we must assume that the subsidence from A and B to A^1 and B^1 has been vertical; but in that case the portion of the section A D, which by hypothesis has not sensibly contracted by cooling, and which has not suffered flexure, can assume its new position $A^1 D^1$ only by



the relative displacement of D^1 60 yards nearer to C^1, and a general displacement of the whole section $A^1 D^1$, which will gradually increase from A^1 where it is *nil*, to the maximum at D^1. The same displacement in the opposite direction would occur in the subsidence of E B to $E^1 B^1$.

Between the surface A B and a stratum lying at some depth, probably considerable, where the rate of cooling would be sensibly the same as that of the nucleus, there must be an intermediate condition of portions of the crust which well deserves notice. The lines $A^2 B^2$ and $A^3 B^3$ represent the condition of some portions of the crust where the amount of cooling during the assumed period has caused a contraction of 50 yards and 100 yards respectively in the length of the portion lying between the verticals A B^3 and B B^3. In each case the insufficient contraction of those portions of the crust must be supplemented by some flexure and disturbance of the strata, but the deeper we descend, and the more the rate of cooling has approached to that of the interior, the less disturbance will have arisen.

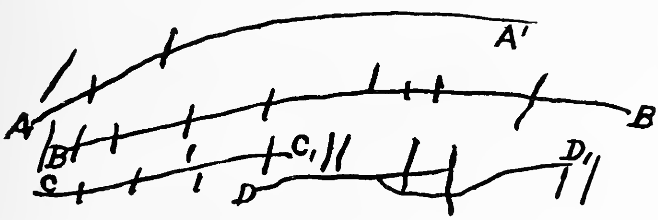
In the illustration here proposed, it will be seen that if the zone of least resistance had happened to lie due E. and W., every meridional section across the same area would show the point of maximum flexure at the centre, and we should have a single mountain chain running due E. and W. across the middle of the area; but if the zone of least resistance should happen to lie in some direction not perpendicular to the meridian, we should have a series of parallel ridges arranged as in the annexed figure, where M N represents the zone of least resistance, and the broad black lines the axes of as many systems of parallel ridges. The fact that such a



disposition of mountain ranges frequently occurs, is familiar to all who have studied the orography of the Alps and other high mountain districts.

In the incalculable lapse of geological time during which the same causes must have continued to cause disturbances of the outer crust of the earth, but under varied conditions of resistance, it is clear, on the one hand, that the direction in which the force of compression would act on a given portion of the surface would be liable to continued but slow variation, and on the other, that there must be an interdependence between the disturbances arising in adjoining regions, even though these should cover very large areas. As a general rule it seems inevitable that a mountain district once formed would become for the surrounding regions a zone of least resistance, which would be liable to undergo new flexures according as pressure came to operate in new directions, and that we ought to find the traces of such transverse compression in the formation of parallel ridges lying at various angles to the main lines of flexure, and at the same time that these secondary ridges should be far less regular than the primary ridges and furrows which mark the earlier corrugations of the surface.

In considering the mechanical effects of lateral compression applied transversely to the direction which has caused the earlier and predominant flexures of the surface, we are led to speculate on the probability of fracture owing to the inability of the ridges to yield to the necessary extent in a new direction. The actual occur-



rence of such fractures would depend upon the plasticity of the materials ; but the summit of each convex flexure would necessarily sustain a tension competent under given conditions to cause rupture. It can scarcely be by an accident that the annexed figure, which appears to be an ideal illustration, does actually represent, in a rude fashion, the main ridges and transverse valleys of western Switzerland and northern Savoy. If the lines A A', B B', C C', and D D' be taken to represent the axes of elevation of the Jura and the chief ranges of the Alps, the reader will have no difficulty in identifying in the short longitudinal lines the valley of Chambéry from Montmelian to Culoz, the valley of the Chéran, that of Annecy, the gorge of the Isère between Albertville and Montiers, the defile of Maglan, the valleys of Montjoie, Bonneval, and Tignes, the Val d'Entremont, and that of the Rhone from Martigny to Vevay, the Eringer Thal, Einfisch Thal, Saas Thal, the pass of the Simplon, the Valley of Hasli, the Valley of the Reuss, &c. It will not escape notice that nearly all the transverse valleys above enumerated, and many others of less importance that might be added to the list, are wholly or in part narrow defiles. There can be no doubt that water and ice have contributed largely to give them their present form; but the same causes have acted elsewhere without producing the same general character of valley.

This is not the occasion on which to attempt to apply in detail the principles here advocated, nor do I pretend to have the requisite amount of special knowledge. They appear to me to account for a large number of the broader facts of general orography, and more especially for many of the peculiarities in the conformation of the Alps that have attracted the attention of geologists. Of the former class I may instance the almost continuous zone of mountains that traverse the eastern hemisphere between the 30th and 50th parallels of latitude, throughout which the prevailing tendency of the ridges approaches to parallelism with the equator, together with the general tendency towards a meridional direction in the ranges N. and S. of that zone.

Of the leading facts of alpine orography which find their explanation in the development of the views here propounded, I would in the first place note the connection between the principal peaks and the secondary ridges that diverge from the main ranges of the Alps. The secondary ridges again, in their turn, very frequently show in their outline a succession of prominences and depressions which sometimes present a remarkable accordance on the opposite sides of a deep valley, and are most easily explained by considering them to result from the intersection of transverse lines of flexure—one set of furrows being represented by the existing valleys, and another by the inequalities in the ridges which enclose them. Another indication of the same phenomenon is apparent in the ancient lake-basins, very frequently filled up, which recur in succession as we ascend through so many valleys in the Alps. As already remarked, these lake-basins were formerly larger and deeper, being almost invariably separated by narrow defiles cut through barriers of rock which once enclosed them.

The formation of several of the greater lakes of Switzerland, which have been called lakes of erosion, may be shown to be the natural consequence of the continued action of the causes here pointed out. It will be obvious that whenever forces adequate to cause flexure act upon a mountain district in a direction different from that which has produced the pre-existing undulations of the surface, they will leave in the new ridges which they originate distinct evidence of their action, and, generally speaking, of the period at which they operated. But when the direction coincides with that of forces previously impressed upon the surface, the whole effect of the renewed action in the same direction will be to increase the existing inequalities, raising the ridges, and deepening the valleys, without leaving any indication of the period at which the action was resumed, or whether it had ever been interrupted. The great ridges and depressions which have determined the main features of the Alps, which in Switzerland and Savoy lie between W.S.W. and E.N.E., and in the Eastern Alps are directed more accurately from W. to E., are the aggregate results of the action whether constant or intermittent, of lateral compression ever since the elevation commenced, a period which probably extends from the origin of the earliest palæozoic rocks to the present time. Though the conception is fundamentally different from that of local subsidence, the effect may sometimes be scarcely distinguishable.

That the meiocene period was one of immense duration is sufficiently proved even to geologists who know the formation only in Switzerland; and it is equally certain that it was accompanied by considerable disturbance of the surface. I can see no difficulty in admitting the probability of the action of forces transverse to the main chain of the Alps and the Jura during, and subsequent to, the meiocene period, which would have deepened previously existing depressions on the site of the lakes of Neuchâtel, Bienne, Morat, and the western part of the Lake of Geneva. The eastern part of the latter lake has probably a different origin. There is nothing, so far as I know, in the country between Bex and the Triassic rocks of Meillerie to make it unlikely that a lake may have existed there before the meiocene epoch.

I shall very briefly notice a few of the difficulties which occur to some minds in regard to the main principles which are here very imperfectly developed. It is sometimes objected that the formation of ridges and furrows upon the rigid crust of the earth in the manner here suggested, without corresponding undulations of the more deeply situated portions of the crust, assumed to be viscid from high temperature, implies the formation of hollows and vacant spaces, owing to the want of conformity in the flexures of the upper surface with those of the inner mass. Without stopping to discuss the possibility of the occasional occurrence of such vacant spaces in certain strata, aided, it may be, by the more rapid cooling of the earth's nucleus which some suppose to have proceeded during preceding geological periods, I reply that the objection rests upon an imperfect idea of the action of force upon the solid materials of the globe. I have no doubt that all rocks possess in some measure that property which, when highly developed, we call *plasticity*, under the action of adequate force applied with the requisite slowness. During the process of flexure, as I understand it, a portion of the earth's crust lies, as it were, in a mould, which changes its form, it may be, at the rate of a few yards in a million of years; and the same quality which permits flexure permits that limited degree of mobility of the parts which suffices to fill up the space that would otherwise be vacated by the flexure. The fact that such an effect has been produced is constantly exhibited on a small scale in the natural sections that abound throughout the Alps, wherein the existence of unconformable flexures is shown not to lead to the formation of hollows in the interior of a contorted mass of rock.

Another objection of a general character is derived from the existence of large portions of the earth's surface which exhibit no traces of considerable flexure, although the hypothesis requires us to admit the continued action, during an immense period of time, of forces competent to cause vertical disturbance. This objection has been partly anticipated in the preceding pages. It has been shown that at the time when the existing inequalities of the surface began, some adjoining regions may probably have escaped displacement, except a moderate amount of lateral shifting towards the area of disturbance; and it has been remarked that a mountain district, once formed, would probably continue to receive new flexures and thereby relieve the pressure on the adjoining areas. Furthermore, in reference to certain districts where very ancient sedimentary rocks appear to have remained nearly undisturbed, it is not impossible that overlying and more contorted strata may have been removed by denudation, and that the earlier strata may have partly escaped flexure for the reason already pointed out, viz. that they in some measure kept pace with the rate of cooling of the deeper portions of the crust.

The objections apparently most formidable, and of which I do not doubt that a numerous array may be adduced by men so well versed in the local geology of the Alps as M. Desor and Professor Ramsay—not to name others whose views I may controvert—rest upon the apparant discordance between the stratification of the sedimentary formations, and the flexures indicated by the present relief of the surface. I have no doubt that there are many facts apparently opposed to the views here advanced which I should find it difficult or impossible to explain: but I would observe that the problems raised are of extreme complexity; and if I am right in believing that the present conformation of the Alps is the complex sum of the operation of forces of compression in various directions, and under varied conditions, through an enormous period of geological time, I am entitled to assume that the unraveling of so tangled a network of causation must be a matter of all but insuperable difficulty. It will be obvious that, in studying the relations of the stratification in successive formations, we have to determine the probable condition of the surface at the time when each was deposited, and the various flexures which it has since undergone, which would differently modify the disposition of the beds according as they led to fracture, or bent the mass without breaking its continuity. Add to these the effects of denudation on an immense scale, and the minor, but still important, mechanical action of water and ice, and it is not surprising if many difficulties long remain unsolved. At present the important point is to find the true clue through the labyrinth. Of some of the main difficulties in alpine stratification, and especially of what has been called the fan structure, I think that the hypothesis here advanced gives a better explanation than any other that I know. The final decision may probably await more minute and persevering study of the structure of the Alps than has even yet been given, although the names of great geologists, deceased or still living, seem to contradict the suggestion.

The hypothesis of lateral compression, in the form in which it presents itself to my mind, is absolutely inconsistent with the maxims of the cataclysmal school of geology. If mountain chains owe their elevation to the gradual cooling of the earth, it is a flat contradiction of the laws of physics to infer, as an American writer has done, the possibility of the sudden elevation of a mountain a mile in height, or even an incomparably less amount of rapid disturbance. More cautious reasoning should lead us to expect that the vertical disturbances would be absolutely insensible, but that the lateral displacements, encountering greater and more unequal resistance, might sometimes cause sensible effects. Whether we may here find a cause of earthquakes, indirectly connected with the elevation of certain mountain chains, is a question which I am not now prepared to discuss.

It is scarcely necessary to advert to exceptional causes which may have operated in the formation of certain mountain-valleys.

For instance, in the Eastern Alps there seems reason to suppose that the chemical changes which led to the formation of dolomite were accompanied by contraction in the mass of corresponding portions of the Jurassic rocks, causing irregular cracks and fissures, which, enlarged by marine action, have produced the irregular disposition of the valleys, and the characteristic forms of the peaks in that district.

To conclude, I am persuaded that there is no single valley of the Alps that does not owe its present form in great part to the action of glaciers, and it is a great gain that all the modes of action of this powerful agent should be fully studied; but, while believing that the main features of the surface have originated in more general causes, I feel surprise that Professor Tyndall has not referred more pointedly to another agent which has surely had even a larger share than that of glaciers in fashioning the great alpine masses. He rightly rejects running water as a means of extensive excavation, but he does not seem to have considered the effects of long-continued marine action upon steep rocks. By that agency alone, exerted during the gradual emergence of the main chain of the Pennine Alps, does it seem possible to explain such an operation as the hewing out of the stupendous peak of the Matterhorn, whose origin must doubtless have occupied his speculative faculties during those daring expeditions that have so nearly led him to that summit which alone seems able to defy the utmost efforts of the present race of mountaineers.

PART II.

TWO distinguished Italian geologists, MM. B. Gastaldi and G. de Mortillet, have recently published letters* in which they seek to controvert the objections which have been raised to the theory of the formation of alpine lakes first published in 1859 by the last-named writer.

M. de Mortillet devotes some pages of his letter to the discussion of objections to his theory incidentally urged by me in a paper published in this Journal in the month of February last. The immediate object of that paper was to controvert views respecting the former extent of glacial action which had been advanced in this country by Professors Tyndall and Ramsay; and to that portion of my argument I understand that both writers give their assent. Neither they, nor, so far as I know, any other of the Swiss or Italian geologists who have studied this question, believe with Professor Tyndall that glaciers have been the main agents in the formation of alpine valleys, nor with Professor Ramsay that they are competent to excavate the deep rock basins, or troughs, that now contain the lakes of the Alps.

As the few observations which I made with reference to M. de Mortillet's theory have been evidently misapprehended by that gentleman, I am anxious to state rather more fully the objections which I have to advance, together with some evidence bearing on the subject that I have recently obtained.

*In vol. v. of *Atti della Società Italiana delle Scienze Naturali.*

The broad facts as to which there is a general agreement amongst those who have discussed this subject are as follows :—

1. The low country at the south side of the Alps, extending about 240 miles from the Isonzo to the west of Piedmont, is covered with a deposit of rolled stones, gravel, and sand, which has been generally called *diluvium*, but to which M. de Mortillet gives the name *ancient alluvium*.

2. Towards the opening of the great alpine valleys the diluvium, which extends for a greater or less distance into each of them, is found to be composed of rocks derived from the mountain-district drained by the valley. At a distance from the base of the Alps the materials of the diluvium spread over the plain exhibit a mixture of the rocks derived from different valleys.

3. There is no appearance of any local disturbance of the surface throughout the region in question since the deposit of the diluvium. The latest changes arising from upheaval of the surface must have been completed before that period.

4. All the main valleys descending from the Alps exhibit unequivocal traces of the action of ice. The glaciated surfaces of hard rock, the presence of erratic blocks perched upon steep slopes, and the remains of great moraines at the lower extremity of the valleys, demonstrate the former presence of glaciers, some of which must have been of enormous dimensions, perhaps exceeding 100 miles in length, and 2000 feet in thickness.

5. The deposit of the terminal moraines of these ancient glaciers must have been subsequent to that of the diluvium, as in many places the former may still be seen resting on the latter.

6. Throughout the central portion of the chain, extending from Domo d'Ossola to Riva in the Italian Tyrol, the principal valleys of the Alps contain narrow and very deep lakes, all of which lie within the area marked by the former action of ice.

Starting from these data, and rejecting Professor Ramsay's theory of the excavation of the lake-basins by glaciers, MM. Mortillet and Gastaldi argue that, as the material of the diluvium are derived from the upper valleys of the Alps, the lake-basins must have been filled up when these materials were borne down to the plain of northern Italy. Refusing to admit that ice may have been the material that filled up the lake-beds, they hold that the diluvium must itself have performed this office, and so bridged over the space that must have been traversed before the great masses of diluvial matter can have been discharged into the plain. To account for the subsequent clearing out of the lake-beds, the glaciers are held to have descended into the lower valleys, and scooped out the incoherent masses of diluvium from the hollows which, on the subsequent retirement of the glaciers, became filled by the existing lakes.

This theory leads to two separate branches of inquiry—the one mainly physical, the other mainly geological. It may be asked, first, whether glaciers as mechanical agents are competent to do the work which has been attributed to them; secondly, whether the evidence fairly interpreted leads us to seek their agency in order to explain the phenomena.

In discussing the first question—that as to the competency of glaciers to excavate deep lake-basins—it will be convenient to fix attention upon a single case. The same arguments will apply, *mutatis mutandis*, to others. Taking, then, the former glacier of the Tessin, which descended into the basin now occupied by the Lago Maggiore, and leaving out of account the branch of the Toce glacier which entered the lake-basin between Pallanza and Baveno, we have the following conditions under which the proposed theory must be tested. Admitting that the lake-basin has been partly filled up in modern times, the ancient giacier of the Tessin, formed by the union of many ice-streams, of which the most important was that flowing from the Val Leventina by Faido, reached the level of the lake-basin at or near Bellinzona. The distance from Faido to that town is about 23 miles, and in that space the bed of the valley falls 1573 feet, so so that the average slope is little more than 1 in 80. From Bellinzona to the lower end of the lake an approximately level bed of diluvium would, according to the theory, have extended to the lower end of the lake, a distance of 47 miles. The basin or trough containing this supposed mass of diluvium is in the form of a long valley, for the most part enclosed between steep walls of rock, very sinuous in form, having an average breadth of about two miles, but contracted at one part to about one mile, and enlarged elsewhere to a breadth of three miles. The depth of the trough throughout a great part of its length considerably exceeds 1500 feet, but at one point, about 34 miles from Bellinzona, it exceeds 2600 feet. A rough estimate derived from the ascertained depth of the lake gives the probable contents, supposing it filled up to its present level, at from 15 to 20 cubic miles. The reader is requested to consider how a glacier, under the circumstances here described, could have cleared out this prodigious amount of solid matter. It does not appear to me that those who have written on the subject have considered the mechanical problem at all closely.

The removal must have been effected, if at all, either by the front or tongue of the glacier while it advanced through the channel, or else by some forces brought into play when the mass of diluvium was covered by that of the glacier. I am willing to admit, as I have done in a former paper, that the tongue of the advancing glacier would probably have some slight effect in removing a superficial layer of such matter as the diluvium; but I see no reason to hold with M. Gastaldi that the effect in the case of a gigantic glacier like that in question would be much greater than that seen in existing glaciers. There is no reason why the tongue of a glacier 100 miles long should be thicker than that of one five miles long. The thickness depends on the relation between the rate of advance of the glacier and the rate of melting, and is greatest when a glacier descends rapidly from an upper level to a lower one where it encounters a rapid increase of temperature. A glacier that had flowed for 23 miles through a nearly level valley would taper gradually to a comparatively thin tongue. But the ploughing action of the front of a glacier depends, as I believe, much less on the weight of the advancing mass than on its tenacity. Giacier-ice, as we know, will bend to suit the shape of the rocky channel in which it moves; but some considerable force is necessary for the purpose, and that force is partly expended against the sides or bottom of the channel. Thus it happens that when a glacier descends a rapid slope, and then encounters a less inclined surface, the front does exert a considerable ploughing action, and shoves before it whatever incoherent masses may stand in its way, until it gradually adapts its bed to the new slope on which it has to advance.* I am relieved from the necessity of insisting on the limited power of the front of a glacier to excavate the diluvium, because this is implicity admitted by both my opponents. M. de Mortillet has, indeed, been good enough to give several sections showing portions of terminal moraine resting on the diluvium, in positions where neighboring portions of the same diluvium must have remained in their present position under the advancing front of the glacier.

If we abandon the idea that the glacier of the Tessin during the period of its advance pushed before it fifteen or twenty cubic miles of solid matter that had previously filled the channel of the lake, the next alternative will be to suppose that the glacier advanced until it covered over the underlying diluvium, and that by some agency, not yet explained, it gradually effected the clearing out from the trough of this enormous underlying mass.

If we had to consider a glacier lying in a valley with a slope of, say 5°, over a bed of diluvium a quarter of a mile in thickness, we should infer, from the few observations we possess on the retarding effect of the bed upon the motion of the ice, that the motion of the bottom of the glacier would be less that half of that of the surface, yet sufficient to exert such a grinding action on the subjacent stratum that in the course of ages the whole might possibly be ground down and removed. It would be an essential part of the

*I am willing to admit that this action, exerted at the base of considerable ice-falls, may excavate in the underlying rock basins of slight depth compared to the thickness of the glacier, and may thus have produced some of the tarns seen in high mountain countries. But I believe these cases to be exceptional and unimportant.

process that, as the materials were pulverized, the streams flowing beneath the glacier would carry them away to some lower level in the form of glacial mud or fine débris. If in this imaginary case the slope of the supposed valley were reduced successively to 4°, 3°, and 2°, we should find that the period necessary for the operation of removing the vast mass of underlying matter must be prodigiously increased, as the increasing resistance offered by friction would diminish to a small fraction the onward motion of the ice upon its bed. If the slope were but 1°, we should hesitate to believe in the possibility of such a removal within any calculable lapse of time. Underlying rocks may be scored and glaciated by the under surface of a glacier, though it should advance but a few inches in the year; but the destruction and removal of vast masses of mineral matter require that the motion by which they are effected should be of appreciable amount.

It is needless to say that the above argument applies with still greater force to a glacier supposed to lie on a dead level of vast extent. My conviction is that under such circumstances the resistance offered by the bed would be far greater than that arising from the internal cohesion of the ice. In such a case the upper portions of the glacier would flow over the inferior portions, and the bottom would remain fixed on its bed. Let it not be forgotten that in the case of a monstrous glacier lying in a level channel 47 miles long, gravity would no longer have the least action in urging forwards the lower strata of the ice. The only force that we can imagine to act in impelling these forwards, would be that arising from the onward motion of the glacier in the upper alpine valley before it reached the level channel. But before we can admit that pressure can be transmitted through a vast mass of glacier-ice sufficient to overcome an enormous resistance, as though the whole were a rigid mass, we must burn the observations of Forbes, Agassiz, Tyndall, and other glacier-inquirers, and forget all the results they have recorded. Professor Tyndall found that in one portion of the Mer de Glace a slight increase of resistance to the advance of the glacier caused the longitudinal compression of a section of the glacier 1000 yards in length at the rate of 8 inches daily; and we are asked to believe that an enormously greater resistance, spread over a space 47 miles in length, would not prevent the transmission of force through the lower strata of the ice sufficient to overcome the obstacles to its onward movement. Of course the argument here offered applies *a multo fortiori* if we suppose the bed of the glacier to be concave, instead of being merely a level surface; but there is one further consideration which seems to be, if possible, still more conclusive.

Let us suppose that in the case here chosen for consideration the glacier had by some process, to me inconceivable, cleared out one cubic mile of the diluvium from the lake-basin, and that it were still enabled to exert some grinding action upon the remaining mass, which, at the lowest estimate, must have measured 14 cubic miles. By what imaginable means could this enormous mass of matter have been removed from the hollow trough in which, by hypothesis, it was contained? In the supposed case of a glacier lying in a valley over a stratum of incoherent materials, the streams formed under the ice would carry off the triturated materials as fast as they were formed; but no such agency can be admitted here. The stream that would issue from such a basin would be merely the overflow of the water rising above the margin. My imagination fails to discover any process by which this could carry off the mineral contents of the basin, and continue to do so till this was drained to a depth exceeding 2600 feet.

M. de Mortillet seems to suppose that I am not familiar with instances where the glaciated condition of the rock shows that the under surface of a glacier has ascended over a projecting surface. Such cases must be familiar to all alpine travellers, and may sometimes be traced in connection with existing glaciers; but to infer from these that the entire mass of a glacier could have been urged for miles uphill, with its under surface sliding over the bed, is much as if I should conclude that because a wagon continues to roll down an incline, although a wheel may now and then pass over a stone, the same wagon might of its own accord travel up the incline, where all four wheels must ascend at the same time. When the force of gravity acting on an entire section of the glacier tends to urge it in the same direction as a force acting *à tergo*, it appears that the tenacity of the ice is sufficient to carry particular portions over convex projections in the bed. But we know from direct observation that the tenacity and rigidity of glacier-ice are confined within narrow limits; and if the force of gravity acting on a considerable section of the glacier were ever to act in opposition to the force *à tergo*, the ice acted on by these opposing forces would necessarily move upwards and outwards in the direction of least resistance.

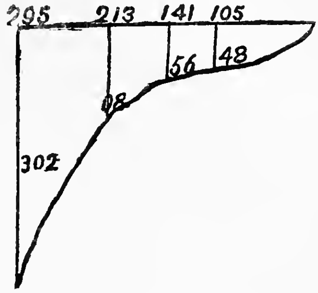
I am well aware that to many geologists arguments derived from mere physical reasoning are not fully satisfactory, and that to such minds the observation of facts seeming to have a direct bearing on the point in dispute will be more conclusive. On this account I desire to mention some observations made during the last summer on a specific point, as to which M. de Mortillet conceived that he had given a satisfactory answer to an objection urged by me.

In the article already referred to, I made the sufficiently obvious remark that if the lake-basins had once been filled by diluvium, and were subsequently cleared out by glaciers, we ought to find the diluvium still *in situ* in those portions of the lake-bed which from local conditions must have been protected from the advance of the glacier. As an illustration, I referred somewhat at random to the rocky promontory of Balbianello, which projects from the west shore of the Lake of Como, nearly at right angles to the general direction of the lake. If the glacier had descended from the north as a gigantic graving-tool, and had scooped out the diluvium from the channel of the lake, the promontory in question would have protected the diluvium lying on its south side, and it should still be found there at the present time. M. de Mortillet at once accepted my argument as a fair test of his theory, and has given what appears to be a sufficient answer, by stating that the diluvium, or ancient alluvium, is actually to be found in the locality which I had quoted. During the last summer I repaired to the place in question with the Marchese Giammartino Arconati, who inhabits the well-known villa on the promontory, provided with about 113 metres, or 370 feet, of sounding line.

It is not necessary that I should give the detail of all the soundings made by me on that occasion; but I desire to direct attention to four which have the greatest significance. It will be sufficient to say that, on sounding from the point of the promontory along its south shore, I found the rocks everywhere descend very steeply, apparently at an angle of about 60° with the horizon. Not only the steepness of the declivity, but the suddenness of the descent from one point to another, showed that we were over ledges of rock rising in a precipice as nearly vertical as is commonly found on the steepest face of a limestone mountain.

Having passed rather more than halfway along the southern shore of the promontory, we found a slight concavity, or very diminutive cove, where lay on a slope, stretching for some yards from the water, a small mass of shingle, consisting of waterworn stones with a little finer gravel. This is evidently the diluvium referred to by M. de Mortillet, and believed by him to be the remains of the vast mass which once filled the entire basin now occupied by the lakes of Como and Lecco. I immediately proceeded to make soundings at successive points in a line receding from the shore, opposite the shingle bank, measuring the exact distance from the shore at which each sounding was made. The result gives of course a rough outline of the vertical section of the bed of the lake opposite to this point, and is best seen in the annexed diagram, where the distance from the shore and the depth at each point are given in English feet, the dotted line showing the outline of the bed.

The fact that the bed of shingle seen through the clear water shelved very gradually from the shore, and the results of the two first soundings, appeared to myself and my companion confirmatory of M. de Mortillet's assertion, whatever the explanation of the fact might be. But the two succeeding soundings, coupled with the fact that at a short distance (less than 10 yards) further from the shore no bottom was found with 370 feet of line, proved to demonstration that the subaqueous precipice is continued along the S. face of the promontory, and that the objection originally taken by me subsists in all its force. I may remark that by following along the shore to the S.W., towards the hamlet of Campo, any one who may repeat the observations will approach the



mouth of a stream which, like every other torrent falling into the lake, pours into it a mass of detritus that doubtless forms a conical mound beneath the level of the lake, not to be confounded with the ancient diluvium.

With the help of the annexed diagram the explanation of the fact noted by M. de Mortillet is sufficiently obvious. On all the more level spots surrounding the lake, extending from the shore to a height of about 2000 feet, deposits of unrolled or partially waterworn materials are to be found. These deposits are formed from rocks existing *in situ* in the alpine valleys surrounding the head of the lake, and were doubtless conveyed by ice to the spots where we now find them. Whether originally waterworn or not, a deposit of such materials exposed for ages to the action of the water on the lake-shore would necessarily be reduced to the condition in which the small shingle-bank in question was detected by the keen eye of M. de Mortillet, and pressed into service as a witness for his theory.

I shall naturally be asked by some who may have followed me so far, what explanation I have to offer of the relations between the diluvium and the more recent glacial phenomena on the south side of the Alps to which M. de Mortillet has called attention. To this I reply that a complete answer cannot, as I believe, be given until the whole of the facts shall have been minutely studied with a degree of care that has not yet been applied to them, and which indeed would not have been practicable until the nature of the problems to be discussed was somewhat defined.

M. de Mortillet has, if I may venture to say so, done excellent service to science by calling attention to the difficulties that have to be explained, and by observations, in many of which he has preceded other inquirers; but he has proposed an explanation which seems to me essentially defective, while he has turned his eyes away from the direction whence light might have been shed on the subject.

MM. Gastaldi and Mortillet have put aside with little discussion the belief expressed by me that the distribution of the diluvium in the north of Italy, and its relations to the undoubted remains of glacial action, cannot be accounted for without admitting the presence of the sea in the valley of the Po during some portion of the glacial period. I have no pretension to speak dogmatically on the subject, but I may say that my conviction on this subject has arisen altogether from observations made during repeated excursions in the southern valleys of the Alps, and has been more and more confirmed as I have found that, although there may not be evidence amounting to direct demonstration, each new visit to the Alps has added to the list of observations which are consistent with this belief.

In the first place, this hypothesis has in its favor no trifling amount of *à priori* probability. There is no evidence whatever pointing towards any local disturbance of level in the Alps since the miocene period; it is therefore the more probable that the entire chain should have participated in any general change of the relative level of land and sea that affected the adjoining regions during the later geological period. We have conclusive evidence to show that in those islands the sea stood during a portion of the glacial period at least 1500 feet higher than it now does. We know also that a considerable part of North Germany was submerged, as well as a still more extensive region in Northern Africa. Leaving out of account other more disputable instances of recent change of level, these facts suffice, as I think, to create a presumption in favor of the view which I advocate, and which, if I mistake not, is supported by the high authority of M. Omboni.

One of the main reasons which makes probable the presence of the sea in the valley of the Po, is the wide dispersion of the diluvium throughout the great plain at the foot of the Alps. The diluvium is not merely found at the opening of the main valleys that penetrate deeply into the interior of the Alps; it is spread along the base of the entire range, in situations quite out of the path of those imaginary currents that are said to have swept the rolled débris from the valleys into the plain. In some places, as on the plain of Friuli, it is spread out on a dead level in a uniform stratum, without the slightest break, and with scarcely a ruffle on its surface. These are effects which no currents of running water are competent to produce. No known cause, excepting the waves of the sea, or of a great lake beating on a shallow bed, will spread out shingle in the fashion which we see in Northern Italy.

It is supposed that because the diluvium consists of materials derived from the upper valleys of the Alps, and because it is composed of waterworn fragments, it must have originally been conveyed to the plain in the condition in which we see it. The inference appears to me altogether unnecessary, and, for reasons presently to be mentioned, very improbable. I believe ice to have been the main agent for the transport of the diluvium as well as the moraines, and that its waterworn character is due to trituration by wave-action on a shallow shore. Besides the difficulty of admitting that currents descending the valleys can have coated the plain with a uniform stratum of diluvium, it is equally hard to understand how they can have carried the diluvium across the level lake-basins, supposed to have been filled up, so as to reach the plain. A slope of at least 10 feet per mile, or 1 in 500, is necessary to enable a river to transport rolled gravel of the size required. This objection has been perhaps overstated by Lombardini, but is clearly a serious one. We ought to find traces of diluvium at a great height about the head of each of the greater lakes. No such traces have been found. Even if great currents were able to transport and spread out the diluvium as we now find it, which I cannot concede, it is not easy to see how such a violent and continuous current as is required can have originated in each of the alpine valleys. The estimate of rainfall cannot be reasonably increased beyond moderate limits; and the greater cold of the climate, by increasing the proportion of snow in each fall, would have tended to diminish the violence of the current, and to make it more uniform in volume. The only cause likely to have acted at all has not been pointed out, so far as I know. During the period of increase of the glaciers, cases may probably have arisen in which a main valley was barred across by a glacier descending from some lateral gorge or glen; and a lake having accumulated behind the barrier, this grew until it burst its bounds, and caused a flood of the same character as the well-known inundation of the Dranse in 1818. But such events must have always been of a local and accidental character; it is impossible to look to them for the explanation of a phenomenon so vast and so general as the transport of the diluvium. In connection with the preceding paragraphs, it is worth noting that the Dranse inundation, the most considerable event of this kind accurately recorded, does not seem to have carried any coarse débris below St. Maurice in the Valais, none certainly was borne nearly so far as Villeneuve.

Several writers on the glacial period seem to have taken it for granted that very extensive glaciers must have produced streams vastly more considerable than those that now flow through the alpine valleys. A moment's consideration shows that this is a mistake, if we admit that whatever climatal changes may have occurred during the period in question were gradual and not abrupt. Any other supposition would imply the sudden destruction of most of the existing species of animals and plants. During the period of the increase of the glaciers a part of the rainfall of each year would have been converted into névé, and conversely, during the period of decrease a corresponding portion of glacier-ice would have been annually melted. The streams could have been no greater than sufficient to carry off the annual rainfall, diminished in the one case, and increased in the other, by the quantity gained or lost by the glacier.

Believing as I do in the presence of the sea in the valley of the Po during a portion of the glacial period, I am prepared to believe that amongst the effects hitherto attributed to glaciers alone, some portion may be due to the action of floating ice. It seems to me highly probable that during the earlier portion of that period the sea entered into the main valleys on the southern side of the Alps, and that moraine-laden glaciers entering these fiords were floated down to the open sea, where they would rapidly melt, depositing their burdens at the sea-bottom. At a later period it seems probable that the sea-level gradually fell, while the glaciers advanced and gradually filled up the lake-basins, finally depositing their moraines about the openings of the greater valleys. Considering the enormous mass of mineral matter brought down during this period, the operation must have covered a vast extent of time; and analogy would lead me to expect that the changes of climate were not uniform. There are indications of halts, during which the glaciers were stationary, and of oscillations that probably caused their retreat and subsequent advance. The time necessary for the melting of such a mass of ice as would have filled one of the great lakes is so great, that it is probable that they may have been partially or entirely occupied by ice after the glacier had retreated to a considerable distance in the valley above the lake.

In regard to some of the vast piles of débris that have been described as moraines of extinct glaciers, and especially those south of the Lake of Garda, it appears to me that a considerable portion was accumulated by the stranding of ice-rafts, or masses of floating glacier on the shallow sea-bottom opposite the mouth of the valley. Some considerable portions of the mass are flattened out and accurately levelled at the top, in a way altogether inconsistent with the idea of their being ordinary moraines left *in situ* by the retiring glacier. It is not allowable to suppose that the lake itself, when formed by the melting of the glacier, can have done this work, unless we admit that at the period when the moraine amphitheatre was formed the sea beat upon its outer face at a level considerably above the present plain. In that case the streams cutting through the terminal moraine to give exit to the drainage of the glacier would have gone as low as the then sea-level, but no lower; so that at a later period, when the sea had retired, and the lake was formed by the melting of the glacier, this might have been kept at a higher level, being held in by the circuit of hills constituting the terminal moraine, which would have been gradually cut through by the Mincio. During the interval, the lake, acting on the materials lying within the amphitheatre, may have modified their form and arrangement, though I think the appearances agree better with the supposition that the level-topped mounds were formed from stranded ice-rafts, as already mentioned. If the glacier when at its furthest had advanced into the plain, this being formed of dry land, the action of the streams issuing from the glacier would have kept a channel open, and no bar would have been formed by the terminal moraine capable of holding up the level of the lake.

It is only by careful levelling along the banks of the lakes, and the alpine valleys connected with them, that it will be possible to distinguish accurately between the traces of extinct glaciers and those of floating ice. Many peculiarities in the distribution of erratic blocks and glacial drift in the valleys of the eastern Alps would lead me to believe that the sea, during some part of the glacial period, must have there reached a considerable height, approaching, if not exceeding, 1800 feet above the present level; but without more complete and more accurate observations I place no confidence in this conclusion.

I think I have shown in the foregoing pages that the theory of M. de Mortillet involves a chain of hypotheses each of which is inadmissible.

It is not admissible to assume that violent currents existed in each of the valleys of the Alps, capable of bearing down such an enormous amount of diluvium as would have filled up the great lakes; it is inadmissible to assume that, if such currents did exist, they could have carried the diluvium along the level floor of the lake-basins so as to reach the plain; it is not admissible to assume that, if it had reached the plain, it could have been evenly spread out over the surface by the supposed currents; lastly, it is an assumption entirely inadmissible that the lake-basins, if filled with diluvium, could have been cleared out by glaciers. Whatever may be the true solution of the interesting problem proposed by M. de Mortillet, that furnished by him will not, I feel sure, be accepted by geologists.

I believe that, in indicating the presence of the sea in the valley of the Po, I have pointed out the quarter whence a true solution of the difficulty is to be derived. The solitary argument that seems to be relied upon by M. de Mortillet to negative this belief, is the fact that marine remains have not been discovered in the diluvium. If negative evidence of this nature were held to be conclusive as to the validity of geological theories, we should have to alter many of the received doctrines of the science. Deposits of enormously greater extent than the diluvium in the valley of the Po are universally believed to have been formed by marine action, although no marine fossils have yet been identified in them; and it is especially in regard to strata formed of rolled fragments of hard rock that we should expect the destruction of whatever scanty organic remains they may once have contained. I may be allowed to cite the following facts as illustrative of the small value of negative evidence in regard to the very geological period now under discussion. The presence of the sea at a considerable height on the mountains in the British Islands during a portion of the glacial period is now universally admitted; but no marine remains have been found on the lower western slopes of the mountains of North Wales, although these must have been in succession portions of the shore during the advance and subsequent retirement of the sea. Only in two or three spots, at a height of from 1200 to 1350 feet, have sea shells been found. The chief deposit, first discovered by Mr. Trimmer, is near the summit of Moel Tryfaen, a sharp conical peak, where no one would suspect its presence. From this locality, as I have been informed by Sir Charles Lyell, fifty-six existing species of shells, for the most part Arctic or northern British, have been extracted, while in another spot, where similar remains were detected by Professor Ramsay, but few and imperfect fragments have been found. When it is remembered that the district in question has been over and over diligently examined by careful geologists, the absence of organic remains over so wide an area affords a striking commentary on the value of negative evidence in geology.

Even though the presence of salt water in the valley of the Po during the glacial period were absolutely disproved, this would not remove the possibility of the existence of an inland freshwater sea in the same area, whose physical effects in the production and diffusion of the diluvium would have been undistinguishable.

While correcting the erroneous statements of Sonnini and others, the labors of Admiral Smyth have verified the existence of a bar extending from Sicily to the opposite coast of Africa; and in the Adriatic it is well known that the depth of the bottom between Otranto and the opposite coast, though considerable, is much less than either north or south of the "narrows." This is not the occasion for discussing the probability of recent changes in a region which has long been the seat of intense volcanic action; it is enough to say that, if the rein be given to speculation, it may take other directions than that in which it has been set free by M. de Mortillet.

The broad facts are simply these, that an enormous quantity of mineral materials has somehow been transported from the central portions of the Alps to the valley of the Po; that the older part consists of a waterworn deposit spread out over the plain, while the newer portion assumes the shape of mounds of unrolled or slightly worn materials disposed about the opening of the main valleys. All are agreed that these mounds are moraines, partially or exclusively deposited in their present site by glaciers which descended the valleys and filled up the basins of the lakes, where such were present in the path of the extinct glaciers. The same vehicle was equally competent to convey the materials of the diluvium; but we have no direct evidence to show how this was reduced to its present rolled and waterworn condition, nor how it was spread out over the low country. It is only by full discussion of the problems remaining to be solved that we are likely to arrive at reliable solutions, and it is to this end that I have offered the foregoing remarks.

III.

GLACIERS OF THE HIMALAYA MOUNTAINS AND NEW ZEALAND COMPARED WITH THOSE OF EUROPE. ON THE POWERS OF GLACIERS IN MODIFYING THE SURFACE OF THE EARTH, AND IN THE AGENCY OF FLOATING ICEBERGS. BY SIR RODERICK I. MURCHISON, K.C.B. PRESIDENT OF THE ROYAL GEOGRAPHICAL SOCIETY. FROM PRESIDENTIAL ADDRESS IN JOURNAL OF THE ROYAL GEOGRAPHICAL SOCIETY, LONDON, VOL. XXXIV, 1864.

IN the last Anniversary Address I directed your attention to the state of Greenland as it is, in order to impress upon the minds of our Fellows who have not attended to the connection between existing geography and the ancient conditions of the globe, that Scotland and large portions of Northern Europe must, at a period anterior to the creation of man, have been in the same condition as that in which Greenland and its adjacent seas are now. In other words, that, in the glacial epoch of geologists, certain elevated tracts were permanently occupied by fields of snow, with glaciers descending from them to the bays and cliffs of the sea, and that the erratic blocks which we now find spread over central England and the plains of Germany are simply the relics of icebergs which floated over wide tracts then submerged, and which, on melting, dropped them on the then sea bottom.

In the last session the vivid descriptions of the glaciers of Western Tibet, by Captain Godwin Austen, and of the glaciers of the middle island of New Zealand, by Drs. Haast* and Hector,† have specially attracted the attention of the Society; and I am therefore

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*Dr. Haast (as before-mentioned) has sent to our Society a series of colored sketches of the Glaciers of the Western Coast of the Province of Canterbury, which for striking effect seem to me never to have been surpassed by any delineator of icy regions. The juxtaposition of these glaciers to a splendid forest vegetation, and amidst mountains which are close to the sea, and yet rise to 10,000 feet above it, the depth of the gorges, and the height of waterfalls issuing from the ice, are all very remarkable.

By a letter just received from Dr. Hector, dated 20th January, 1864, I learn that not only has he ably explored the region occupied by glaciers in the province of Otago, but has also visited, in a steamer, the wonderful fiords on the western side of the island. He is now preparing a work on the geological structure of the colony, in which he will show that the lakes on the eastern slopes of the country are true rock basins, which were once occupied by glaciers, and the bottom of one of which sounded by him has a depth of 1250 feet, or considerably below the sea. Although Dr. Hector does not go so far as to express his belief that these rock-basins have been scooped out by ice, he suggests that they have been filled and shaped by glaciers. He avows, however, that he has to read up much on this subject, and I only regret that this portion of my Address cannot probably be in the hands of my distinguished friend before his final conclusions may be published.

led to dwell on these grand terrestrial phenomena by giving a general view of the results of glacial action, both terrestrial and subaqueous.

When the first of those Memoirs was read, Dr. Hugh Falconer, who had passed several years in that same region of the Tibetan Himalayas, enlarged upon the scenes which had been so graphically delineated on maps by Captain Godwin Austen. He then referred us to the works of those who preceded and followed him in examining that region, and reminded us of the names of Moorcroft, Trebeck, Jacquemont, Vigne, Strachey,* and Thomson.

In considering the subject of glaciers, I am bound specially to call your attention to the last-mentioned of these explorers, Dr. Thomson, who first well defined the characters and extent of the glaciers of Western Tibet. In addition to a masterly description† of the physical geography of the regions he traversed, the work of Dr. Thomson is also so rich in botanical, climatological, and geological researches as to be a model for geographical explorers. Thus, his original observations on the enormous lacustrine deposits, replete with the remains of fresh-water shells, accumulated formerly at vast heights above the sea, are to my mind the grandest and clearest proofs of how the feeders of the Indus in bygone periods were dammed up by rock barriers, which later acts of upheavement may have disrupted, or by gigantic transverse or terminal glaciers and their moraines. In truth, therefore, the parallel roads of Lochaber in our Highlands, to which I adverted last year, have their grander analogue in the vast horizontal terraces of the mountains of Tibet. Again, among the remarkable data set before us in that work, is the striking fact that in the trans-Sutlej region of the Himalayas, the glaciers which descend from the southern flank of a range of mountains are longer than those which occur on the northern flank of the same. This is accounted for by the author on the grounds of the great amount of moisture proceeding from the ocean being arrested and condensed into snow by the first great range of heights which it encounters. The same phenomenon was, indeed, met with in Sikhim by Dr. Joseph Hooker, in the eastern portion of this great chain. Unlike his precursors, Thomson, when he wrote, was already conversant with the true laws of glacier movements, as well as the most remarkable of their effects, as pointed out in various works by Agassiz and other writers upon the Alps, and he specially refers to Professor James Forbes; for, though many an ardent traveller had preceded him, Thomson was the first who clearly distinguished the glaciers of the Himalayan Mountains from the snows whence they issued, and who at the same time pointed out the lateral and ter-

* In 1847 Lieut. R. Strachey visited and described the glaciers of the Pindur and Kuphinee Rivers, and applied to them the excellent Alpine classification of Professor James Forbes.

† "Travels in the Western Himalayas and Tibet." 1852.

mina. moraines which they evolved. That which Thomson did for the western or Tibetan portion of this lofty chain of mountains was, in like manner, admirably done by Dr. Joseph Hooker for the eastern mountains of Sikhim, in his most attractive work.*

All these observers, whether in India or in New Zealand, have taught us that the glacial phenomena, though on a much grander scale in the Himalayas, are precisely analogous to those in Europe. The application, however, of accurate topographical surveying, and the ascertainment of the precise length and breadth of those grand rivers of ice, were wanting. Captain Godwin Austen has effected this, as regards those vast glaciers proceeding from the Mooztagh, which lie to the west of those descending from the Karakorum Pass, described by Thomson. Having measured the length and breadth of these masses, he has enabled us to know that one of them, which feeds the powerful affluent of the Indus called Shiggar, has a length of 36 miles, and is therefore upwards of three times the length of any existing glacier of the Alps; though it will presently be shown that some of the old Alpine glaciers were considerably longer. Well, indeed, may we account for these enormous dimensions now existing in the Himalayas, when we recollect that the passes by which travelers proceed to Yarkand have a height of 18,000 feet, and that the great Karakorum Peak rises to 28,200 feet, above the sea. Captain Godwin Austen is, I understand, about to explore the great *terra incognita* which the Burhampooter is supposed to traverse in the upper part of its course, and we may confidently hope that, at no distant day, this energetic young officer will ultimately obtain the highest honors of this Society.

In the discussion which followed the reading of the memoir of Captain Godwin Austen, Dr. Falconer grappled most ably with the novel theory that the lakes of the Alps owe their origin to the erosive action of ice, which, descending from former great glaciers, has excavated or scooped out the cavities now filled with water. Being one of the few men who have personally examined the glaciers both of the Himalayas and the Alps, his reasoning from observed facts is most valuable. Believing, with the vast majority of practical geologists, that the irregularities of the surface of the Alps have been primarily caused by dislocations and denudations, he gave it as his opinion that the Alpine cavities, having been filled with ice during the glacial period, were thereby protected from the influx of the vast masses of the detritus hurled down in the moraines of gigantic glaciers that passed over these countries on solid ice, which, on melting, left the depressions in the condition of lakes. On the southern flank of the Himalayan mountains, on the contrary, where ice has not acted as a conservative agent, the valleys have been

* See "Himalayan Journals." 1854.

choked up with débris, but no great lakes exist. Dr. Falconer expressed the same views at an evening meeting of the Geological Society, on the 5th March, 1862, but it is not the practice of that body to record the opinions of speakers.

In alluding to this original view of Dr. Falconer, and to his able illustration of the whole subject, as detailed in our Proceedings,* I am bound, as a geologist, not to shrink from stating that I agree with him. I beg also to take this opportunity of recording my own opinion of the effects which glaciers have produced in those tracts where they formerly existed, or where they now prevail, as founded on the observations of many good observers, as well as on my own researches. Until lately geologists seemed to be generally agreed that most of the numerous deep openings and depressions which exist in all lofty mountains were primarily due to cracks, rents, and denudations, which took place during the various movements which each chain had undergone at various periods. These apertures, it was supposed, were necessarily enlarged by long diurnal atmospheric agency and the action of torrents carrying down boulders and detritus; such action being most intense in those mountains where snows and glaciers prevailed, the melting of which necessarily produced great débâcles. In the place of this *modus operandi*, another theory has been applied to all those mountains, which, like the Alps, have been for long periods the seat of glaciers.

Before I enter on the consideration of the new theory of the power of moving ice, let us take a review of the progress recently made in pointing out the extent to which ancient glaciers and their moraines have ranged within or on the flanks of the Alps. In the northern portions of the chain these phenomena long ago attracted the attention of some admirable observers. Originating with Venetz and Charpentier, the true active powers of glaciers were defined by Rendu, Agassiz, and Forbes, and subsequently by the other explorers. In short, no doubt any longer obtains, that such was the powerful agency of the grand ancient glaciers, that blocks of crystalline rock were transported by them from the central Alps of Mont Blanc to the slopes of the Jura Mountains. When, however, we begin to seek for satisfactory explanations of the method of transport of these huge erratics, geologists (who are only geographers of another order) entertained different opinions. For my own part, I have had strong doubts as to whether the great blocks derived from Mont Blanc, and which lie on the slopes of the Jura were ever borne thither by a vast solid glacier which advanced from the Lake of Geneva over the Cantons of Vaud and Neufchâtel. Whilst fully believing in the great power of glaciers and their agency, my opinion was that these blocks were rather transported

* "Proceedings of Royal Geographical Society," vol. viii. p. 38.

to their present habitats on the Jura on ice-rafts, which were floated away in water to the N.N.W., when the great glaciers melted, and the low countries were flooded. I founded this opinion on the fact, that in examining the Canton de Vaud, and particularly the tracts near Lausanne and the north side of the Lake of Geneva, I never could detect the trace of true moraines. In that detritus I saw merely accumulations of loose materials, which had all the aspect of having been accumulated under running waters. But, even granting to the land-glacialists their full demand, and supposing that a gigantic glacier was formerly spread out in fan shape, as laid down by several geologists and recently in the little map of Sir Charles Lyell, in his work on the Antiquity of Man, and that it became eventually of such enormous thickness as to have carried up the great blocks on its surface, to lodge them on the Jura Mountains; there is still in it nothing which supports the opinion, as indeed Sir Charles had himself observed,* that the deep cavity in which the lake lies was *excavated* by ice.

The geologists who first embraced the view of the transport of the huge blocks on the Jura by a solid glacier, were of opinion, that the great depressions and irregularities of the surface which we now see between the Alps and the Jura, including the Lakes of Geneva and Neufchâtel, were so filled up with snow and ice, that the advancing glaciers traveled on them as bridges of ice, the foundations of which occupied the cavities.

Let us now turn to the south side of the Alps, where a long incline accounts for the enormous extension of glaciers into the plains of Italy. Thus, in examining the remains of the old glaciers which once advanced into the valley of the Po, MM. Martins and Gastaldi show us, that one of those bodies extended from Mount Tabor to Rivoli, a length of 50 miles; and, therefore, was longer than any existing glacier described on the flanks of the Himalayas;† whilst those to the south of the Lago di Garda are shown to have had a much greater length. Demonstrating, along with many other authors, how these old glaciers had striated and polished the hard rocks through or on which they had advanced, these authors also clearly pointed out how the course of the glaciers had been deflected, so as to take a new direction, when they met with the obstruction of any promontory of hard rock. Further, M. Martins, being well acquainted with Norway, indicated that, just as in that country, the face of each rock in a valley was rounded off, polished, and striated where it had been opposed to the advancing mass of ice, and that its opposite or downward face, over which the ice had cascaded or tumbled, was left in a rough state; thus exhibiting the

* See "Antiquity of Man," p. 312.

† Bull. Soc. Geol. de France. 1850.

worn or "stoss-seite," and lee, or protected side, of the Scandinavian geologists. The subsequent works of M. Gastaldi on the geology of Piedmont, in 1853 and in 1861, bring within well-defined limits the phenomena of old moraines and ancient drift, and prove that the débris carried over each gorge and valley has been derived from the rocks which specially encase such depressions. He also clearly demonstrated that in many of these cases the gigantic boulders, which are piled together and present the character of a cataclysmal origin, can all be accounted for simply by the power of advancing ancient glaciers. In these works M. Gastaldi very properly distinguishes between the erratic blocks which were evidently parts of old terrestrial moraines, and those which, associated with tertiary strata, are found in deposits with marine shells—the larger erratics in the latter, as in the Superga, having been transported in masses of ice which floated on the then sea.

Various other Italian authors have occupied themselves with glacial phenomena (particularly Omboni, Villa, Stoppani, Cornalia, Paglia, Parolini, &c.): the conclusion at which they have all arrived is, that there existed an enormous extension of the moraines sent forth by the ancient Alpine glaciers into the great valley of the Po. Geographers who have not studied the phenomena may well indeed be surprised when they learn that the hills to the south of the Lago di Garda, and extending by Pozzolengo and Solferino to Cavriano,* or the very ground where the great battles of the year 1859 were fought (the hill of Solferino being 657 English feet above the sea), are simply great moraines of blocks and gravel, produced by the advance of former glaciers which issued from the southern slopes of the Alps.

Combining these observations with others of his own on the lake of Annecy, M. Mortillet suggested in 1862 a new theory, in attributing to the descent of the glaciers a great excavating power. Believing, with all those who have been named, as well as the most eminent of the Swiss and French geologists, that the last great upheavals and denudations of the Alps had produced the irregularities of their surface, he inferred that before the glacial period began, the débris derived from the wear and tear of the mountains by watery action had, to a great extent, choked up the valleys and filled the rock-basins. He further believed that, in the cold period which followed, great glaciers, descending with enormous power, forced all such débris out of the original rock-basins, and left them to be occupied by the present lakes. It is proper here to state that M. Gastaldi was right, as well as M. Mortillet, who followed him, in presuming that great deposits of old water-worn alluvium or loose

*See Paglia—"Sulle Colline del Terreno Erratico all' estremità meridionale del Lago di Garda" (with map).

drift were accumulated before the formation of glaciers, inasmuch as the oldest moraines are seen to repose in many places on the former. It will presently be shown that this fact contains within it the proof that the glaciers were not and are not in themselves excavating bodies.

Preceeding M. Mortillet, however, in reasoning upon the excavating power of former glaciers, my eminent associate Professor Ramsay had broached a much bolder theory. In his essay entitled "The Old Glaciers of Switzerland and North Wales," published in 1859, and re-published with additions in 1860, he expressed the opinion that the excavation of deep hollows in solid rocks was due to a weight of superincumbent ice pressing and grinding *downwards and outwards* over high, flat, and sometimes broad watersheds and table-lands, during that period of intense cold which produced the old glaciers.* In 1862 he went still further; and whilst M. Mortillet was communicating his views on the Continent, Ramsay, wholly unconscious of what M. Mortillet was doing, read a memoir to the Geological Society of London, showing that all the cavities occupied by lakes in Switzerland and the North of Italy had been excavated originally by the action of glacier ice. Whatever, therefore, be the fate of this ingenious view, Professor Ramsay has our thanks for having excited much useful inquiry, and for having compelled old geologists like myself to reconsider our conclusions.

If the view of M. Mortillet has been met with objections, still more is the theory of Ramsay opposed, and particularly in foreign lands. In this country it has indeed met with the most vigorous opposition on the part of Dr. Falconer, as recorded in our Proceedings; and even Sir Charles Lyell, the great advocate of the power of existing causes, has stoutly opposed this bold extension of a most powerful *vera causa.*† Having explored the Alps, at various intervals, for upwards of forty years, I long ago came to the conclusion that their chief cavities, vertical precipices, and subtending, deep, narrow gorges, have been *originally* determined by movements and openings of the crust, whether arranged in anticlinal or synclinal lines, or not less frequently modified by great transversal or lateral breaks, at right angles to the longitudinal or main folds of elevation and depression. Explorations of other mountainous regions, in various parts of Europe, have strengthened this conviction. I rejoice, therefore, to find that those geologists of Switzerland, who justly stand at the head of their profession, Professor Studer and M. Escher von der Linth, have sustained, by numerous appeals to nature, the views I hold in common with the great majority of geologists. Those Swiss explorers, who have labored for many years

*See "Peaks, Passes," &c. (Alpine Journal, 1859), and "The Old Glaciers of Switzerland and North Wales," London, 1860, p. 110.

† See "Antiquity of Man," pp. 316 *et seq.*

in their native Alps, and have constructed admirable geological maps of them, must surely be well acquainted with the ruptures of the various rocks, the outlines of which they have sedulously followed. Now, they attribute most of those deep cavities in which the rivers and lakes occur either to dislocations producing abrupt fissures, or to great foldings of the strata leaving openings upwards where the tension has been the greatest—openings which were enlarged by powerful denudations. Numerous geologists have recently expressed their concurrence in the generally-adopted view, that the Alpine lakes occupy such orographic depressions; and, by close researches, my accomplished friend Mr. John Ball* has ably sustained this view, and has further shown how slight is the erosive power of a glacier even when issuing from its main source. No one of them, in short, any more than Professor Studer and myself, doubts that the origin of these lakes is primarily due to other causes. Nor am I aware that any geologists of France and Germany, much as many of them have examined the Alps, have deviated from the opinion that the main diversity of outline in that chain was due to ruptures and denudations that occurred during the upheavals of the chain.

On the other hand, I am bound to state that, although the new theory has met with little or no favor on the continent of Europe, it is supported by our able geologists, Jukes and Geikie. Again, whilst Ramsay extended his view to the great lakes of the Alps, the eminent physicist Tyndall speculated even upon all the Alpine valleys having been formed by the long processes of the melting of snows and the erosion of ice.† With every respect for the reasoning of my distinguished countrymen, I rely upon my long acquaintance with the structure of the Alpine chain; and now that I see sound practical geologists, who have passed their lives in examining every recess of those mountains, rejecting this new theory, and pointing out, in place of it, the proofs of ruptures and denudations in the chain, I adhere firmly to the view I have long entertained.‡

Those who wish to analyze this matter, must consult the admirable essay of Professor Studer on the origin of the Swiss lakes.§ They will find numerous proofs of the views sustained by the leader of Alpine geologists. He shows you, indeed, how many of the rivers now flow in fissures or deep chasms in very hard rocks of different

* See "Phil. Mag." 1863.

† See Tyndall on the Conformation of the Alps, "Phil. Mag." vol. xiv., 1862, p. 169, and also Ramsay on the Excavations of the Alps, xvi, p. 377.

‡ Some remarkable facts have been mentioned to me in a letter by M. Escher von der Linth, as proving the inapplicability of the ice erosion theory to the Swiss lakes. 1st. That the glacier of Rosenlaui, which descends from a great altitude, does not enter a low deep narrow gorge of the valley, but forms a bridge over it; and so it is to be inferred, that, as the ancient glacier did not excavate this gorge, still less did it excavate the great valley in which the present glacier is embosomed. Again, he points out that, as the bottoms of many of the Swiss lakes are below the level of the sea, the glacier which is supposed to have excavated the hollow would have to ascend considerable heights to emerge from the depression which it had excavated—an impossible movement, and contradicted by the existing operations of all glaciers.

§ "Origine des Lacs Suisses," Biblio. Univ. et Revue Suisse (Arch. des Sci. Phys. et Nat.) t. xix. liv. de Février, 1864; also Phil. Mag. vol. xxvii. p. 481.

composition; chasms which water alone could never have opened out, particularly in those cases where the river has left a softer rock, and, with very slight obstacles to its straight course, has availed itself of one of these deep transverse natural gorges, which have evidently been produced by a great former rent. My personal observations in the Alps, Carpathians, and Ural mountains enable me to confirm this view. As regards the continent of Europe, I should transport you to the Rhine, the Danube, and other great streams, which, flowing through flat countries, with little declivity, never could have eroded those deep, abrupt gorges through which they here and there flow, and which are manifestly due to original ruptures of the rocks.*

In holding these opinions as to the small power of watery or glacial action, when not acting on an adequate incline, I do not doubt that glaciers have been, and still are, most important agents in modifying the outlines of mountains. Their summits are, we know, continually degraded by rains and melted snows; and torrents flowing down from them and carrying much detritus, are, doubtless, deepening their channels wherever sufficient slopes occur. But to whatever extent this agency has been and is at work, and to however great a degree a descending glacier may scratch and round off the rocky bottom on which it advances, I coincide with Professor Studer, and many other observers, that the amount of erosion produced by these icy masses, particularly when they have advanced into valleys where there is only a slight inclination, must be exceedingly small. In valleys with a very slight descent it will presently be shown that, even in the Alps, no erosion whatever takes place, particularly as the bottom of the glacier is usually separated from the subjacent rock or vegetable soil by water arising from the melting of the ice. Again, in all the steeper valleys down which ancient glaciers have formerly descended, we do not find that either the sides or bottoms of the upper gorges afford any proof of wide erosion, but only exhibit the peculiar fashioning of the flanking surfaces of the rocks, or that rounding off and polishing, called *moutonné*, accompanied with striations. On the contrary, in gorges whence the largest glaciers have advanced for ages, we meet with islands of solid rock and little bosses still standing out, even in the midst of valleys down which the icy stream has swept.

With such proofs before us of what the frozen rivers called glaciers have done and are doing in the high valleys, how can we imagine, as Dr. Falconer has forcibly put it, that the glacier which is supposed to have occupied the Lago Maggiore, for example, and

*The recent Russian exploration of Eastern Siberia has shown how the grand river Amur deflects suddenly at nearly right angles from its course in a comparatively low country, to take advantage of a deep natural rent in the mountains through which it escapes to the seaboard (see p. cxl. of the Address).

had advanced its moraines into the plains of the Po, should have had the power to plough its way down to a depth of 2000 feet below the Mediterranean, and then to rise up along an incline at the rate of 180 feet per mile? Nor can I admit the possible application of this ice-excavating theory wherever I see that a depression in which a lake occurs is at right angles to the discharge of an old main glacier. This is remarkably to be noticed in the case of the Lake of Geneva, which trends from E. to W., whilst the detritus and blocks sent forth by the old glacier of the Rhone have all proceeded to the N. and N.N.W.; or in direct continuation of the line of march of the glacier which issued from the narrow gorge of the Rhone. By what momentum, then, was the glacier to be so deflected to the west that it could channel or scoop out, on flat ground, the great hollow now occupied by the Lake of Geneva? And, after effecting this wonderful operation, how was it to be propelled upwards from this cavity on the ascent, to great heights on the slopes of the Jura mountains?

Still stronger objections exist to the application of the excavation theory to the Lake of Constance. There I have never been able to see on the northern flank of the Hohe Sentis, which presents its abrupt, precipitous, and highly dislocated and contorted jurassic and cretaceous rocks to the lake, with terraces of miocene deposits, at various heights,—there I have been unable, when with my indefatigable friend and companion M. Escher von der Linth, who knows every inch of the ground, to trace the signs of the action of a great glacier, which could, in its descent, have so plunged into the flat region on the east and north, as to have scooped out the cavity in which the Lake of Constance lies. In this case, indeed, there are no traces whatever of those great old moraines from the relics of which we infer that glaciers have formerly advanced; the level country to the north of the lake being entirely free from them.

Great orographic depressions and deep cavities, sometimes dry, sometimes filled with water, occur in numberless countries where no glaciers ever existed. Thus, in Spain, as my colleague M. de Verneuil assures me, the large depressions on either side of the granite mountains of the Guadarrama present exactly the appearance which a theorist might attribute to excavation by ice, and yet, however these cavities were formed, it is certain that no glacier has ever existed there. Nor, again, has ice ever acted on the sides of the steep mountains of Murcia, where deep excavations and denudations are seen upon the grandest Alpine scale.

If we transport ourselves from those southern climes to the northern latitudes of the Ural mountains, where doubtless ice and snow formerly prevailed to a greater extent than now, we do not there find any proof whatever of the action of glaciers; for the hills are much too low to have given propulsion to such masses. On the contrary, we know that great blocks of hard rocks have been transported to the foot of these hills from Lapland and Scandinavia, when, during the glacial period, a vast Arctic Sea watered the flanks of the Ural mountains, and when most parts of that low chain could then have been only slightly elevated above the waters. And yet on the sides of this chain, where no glaciers have ever so acted as to have produced erosion, we meet with both longitudinal and transverse deep fissures in some of which lakes, and in others rivers, occur. Thus, all along the eastern flank of the Ural mountains we find a succession of depressions filled with water without a trace, on the sides of the bare and hard rocks which subtend these lakes, of any former action of glaciers. Then, as to deep valleys in which rivers flow, let us take two out of the examples along the western flank of this chain, on which my companions De Verneuil, Keyserling, and myself have specially dwelt in our work on Russia. The Serebrianka river, as it issues from a network of metamorphic schisfs, quartz rocks, and marbles of Silurian age, exhibits on its rugged banks the extrusion of much igneous matter. This agency has split up the stratified deposits; and the necessarily accompanying movements have caused great openings, including the cavity in which the river flows. Or, when the geological traveler passes from the valley of the Serebrianka to that of its recipient, the Tchussovaya, still more is he struck with wonderment at the unquestionable evidences, amidst intensely dislocated rocks, of the ruptures by which the deep narrow chasm has been formed in hard crystalline rocks, in which a lazy stream flows, which, not descending from any altitude, has had no excavating power whatever, and, like our own meandering Wye, has flowed on through clefts in limestone during the whole historic and prehistoric period, without deepening its bed.*

But if rivers which are not torrential, and do not descend from heights, cannot possibly have produced, nor even have deepened, the natural hollows or chasms in which they flow, still it might be contended, that, what water has not effected, may have been done by a river, when, in the compacter form of ice, it descended and advanced across the lower country. Unluckily for the supporters of the ice-excavating theory, the data which existing nature presents to us, as before said, are decisively opposed to their view. The examination of those tracts over which glaciers have advanced, and from which they have retreated, shows, in the most convincing manner, that ice has so much plasticity that it has always moulded itself upon the inequalities of hard rocks over which it passed, and,

* For a full description of the abrupt gorge of the **Tchussovaya**, see "**Russia and the Ural** Mountains," vol. i. p. 352 *et seq.*

merely pushing on the loose detritus which it meets with, or carries along with it from the sides of the upper mountains, has never excavated the lateral valleys, nor even cleared out their old alluvia. This fact was well noticed by the Swiss naturalists, as evidenced by present operations, at their last meeting in the Upper Engadine, and has been well recorded by that experienced and sagacious observer of glacial phenomena, M. Martins.*

Since that time the able French geologist, M. Collomb, who was associated with Agassiz in his earliest researches on glaciers, and has been the companion, in Spain, of my colleague M. de Verneuil, has recently put into my hands the results of his own observation upon the present and former agency of the glaciers of the Alps, which decisively show that ice, *per se*, neither has nor has had any excavating power.† None of the glaciers of the Alps cited by M. Collomb, viz. those of the Rhone, the Aar, the Valley of Chamounix, the Allée Blanche, and the Valley of Zermatt, produce any excavation in the lower grounds over which they pass. That of Görner, which, among others, is advancing, affects very slightly the surface of the meadows on which it proceeds, and does not penetrate into the soil. Again, where the glacier of the lower Aar pushes, on its front, upon accumulations of the débris of old moraines and gravel, it scarcely deranges these materials, but slides over them, leaving them covered with mud and sand, but not excavating them. Also, the glacier of the Rhone, the principal part of which can be so conveniently studied, advances on a gravelly substratum, in which it does not form a channel. Such being the facts as regards glaciers now advancing, M. Collomb cites equally strong, if not still stronger, cases, in support of his view, as derived from the observation of retiring or shrinking glaciers in the valleys of the Alps. Examining last year with M. Daubrée the glaciers of the Valley of Chamounix, he was attracted to that named Bossons, which he had not seen for five years. During that time the glacier had shrunk very considerably, both in altitude and length, and yet upon the surface of the ground from which it had retired there was not the smallest sign of excavation.

Viewing a glacier as a plastic body, we know that it is pressed onwards by gravitation from the increasing and descending masses of snow and ice behind it in the loftier mountains, and being forced to descend through narrow gorges, it naturally acts with the greater energy on the precipitous rocky flanks of these openings; striating and polishing them with the sand, blocks, and pebbles which it holds in its grasp. But, as before touched upon, the narrowness of

* See "Revue des Deux Mondes," Mars, 1864. The former observations of M. Martins on Norway and on the Alps are of the highest importance.

† I may add that M. Collomb expresses that which I believe to be the opinion of Elie de Beaumont, d'Archiac, de Verneuil, Daubrée, and all the leading French geologists.

many of those channels through which glaciers have been thrust for countless ages, is in itself a demonstration that the ice can have done very little in widening the gorge through which it has been forced, and where, of necessity, it exerted by far its greatest power. In other words, the flanking rocks of each gorge have proved infinitely more stubborn than the ice and its embedded stones, which have merely served as gravers and polishers of the granites, quartz rocks, porphyries, slates, marbles, or other hard rocks, among which the frozen river has descended. And, if such has been the amount of influence of advancing glaciers in the higher regions, where the body descends with the greatest power, how are we to believe that when this creeping mass of ice arrived in low countries (as for instance in the depressions occupied by the Lakes of Geneva and Constance) it could have exerted a power infinitely greater than that which it possessed in the higher regions?

When we turn from modern glaciers to the remains of those of ancient date, the proofs are equally decisive, that, whatever might be their extent, those gigantic bodies exercised no excavating power. I am reminded by M. Collomb, as well as by M. Escher von der Linth, that in many parts of the Alps, vast old moraines repose directly on incoherent and loose materials of quaternary age; the old drift of the Alps, containing *Elephas primigenius* and *Rhinoceros tichorhinus*. Well may we then ask, how is it that the ancient and larger glaciers, which were supposed to have had such enormous excating power as to have scooped out deep valleys in hard rocks, should not have entirely destroyed the loose accumulation of gravel over which they have been spread? Or, if glaciers excavated the Lago di Garda and Lago Maggiore, why did they not produce any such effect at Ivrea, in the Valley of Aosta, down which we know that enormous masses of ice traveled; or at Rivoli, in their march from Mount Cenis towards Turin?

Leaving it to physical philosophers, such as Forbes, Faraday, Hopkins, and Tyndall, to show what is the real measure of the abrading power of masses of moving ice, I simply form my opinion from what glaciers are accomplishing, or have accomplished. Judging from positive data, I infer that if, as agents, they have been wholly incapable of removing even the old and loose alluvial drift which encumbered the valleys, infinitely less had they the power of excavating hard rocks. At the same time I know that, in every mountain tract which I have examined, there have been quite a sufficient number of rents and denudations to account for all inequalities. These openings have doubtless been greatly increased by the atmospheric agencies of ages, and particularly in all those situations where water has acted with great power, during the melting of glaciers.

I have made these observations (which I could largely extend) to show the intimate connection which exists between the science of geology, to which I have been so long devoted, and physical geography. Let me explain, however, that I do not doubt that glaciers have, in certain regions, caused the formation of lakes, though by a very different agency from that of the excavation of rocks. The great glaciers of former times have unquestionably sent forth and discharged still larger accumulations of débris than those of our day, which, in the form of high terminal moraines, barred up water-channels, and the result in some mountainous tracts has inevitably been the production of lakes. Among examples of such in Europe, M. Collomb directs my attention to the Gérard-meer, on the western flanks of the Vosges mountains. This lake has been formed by an ancient moraine, which, descending from the Vosges mountains, has been accumulated on old drifted loose materials, which it has not excavated, whilst it has served as a permanent dam to sustain the waters at a height of 1400 feet above the plain of the Rhine, to the east of the Vosges, and nearly 2000 English feet above the level of the sea.

In the grand and loftier cases, however, of Western Tibet, before alluded to, it is scarcely conceivable that icy barriers or moraines in the valleys could have risen to sufficient height to pond back the waters to many thousands of feet above the low country on the south. The bursting of those old vast and lofty mountain lakes was probably, as suggested by Dr. Falconer, determined by the last great upheaval of the Himalayas, which, judging from the very modern character of the organic remains in the upheaved deposits, must have taken place during one of the most recent of geological epochs.

In referring you to my observations of last year on the marvellous effects of those aqueous currents which have transported erratic blocks of stone during the former glacial period, I must attract your notice to a remarkable and faithfully executed new map of Finland by Professor Nils Nördenskiold, of Helsingfors, which illustrates an able memoir by that author on the scratched and polished surfaces of the rocks of his native country.* Carefully taking the direction of every one of the innumerable sets of parallel scratches over a region larger than Great Britain, he shows, that everywhere the direction of these groovings and scratches is from north-west to south-east, with slight local deviations only. Again, the worn sides (stoss-seiten) of each hard rock which has been scratched, worn down, and polished, are presented to the north-west, the point from which the force proceeded; and every *lee*, or protected or rough side, lies to the south-east. On the coast of

*"Beitrag zur Kentniss der Schrammen in Finland." Von N. Nördenskiold. Helsingfors, 1863.

Finland these groovings are even observed to extend in one place from many feet under the surface of the sea. Seeing that the force which produced these groovings and scratches came from beyond the Gulf of Bothnia and the low country of Sweden, and has operated with such uniformity over a vast region, parts of which rose to about 1000 feet above the Bothnian Gulf, he necessarily refers the phenomena to powerful marine currents. These took place when Finland, as well as all Northern Russia and Germany, lay under the sea, and when the chief groovings were made by stones and blocks, which were held fast in the bottom of floating icebergs, when they were arrested on sub-marine banks or points of rock. He also indicates how the erratic blocks dropped by these icebergs are found to be more and more rounded as they have receded from the source of their origin, or how, in drifting to the south-east, they have consequently been more exposed to wear and tear. The quantities of sea-sand which abound, and the accompanying small and water-worn pebbles and gravel, have, of course, assisted in the polishing of the rocks. The sand-ridges and pebble-beds which abound in Finland are, in fact, nothing different from the Ösar of the Swedish geologists; and thus the drift phenomena on either side of the Gulf of Bothnia are shown to be identical sub-aqueous deposits.

Here, then, we have a vast region of Europe in which it is manifest that no land-ice or glacier could ever have acted, inasmuch as the area from whence the force was directed was manifestly far to the north-west of the Gulf of Bothnia, and the low countries of Sweden, which, equally with Finland, are covered with erratic blocks and aqueously transported drift. Neither in the south of Sweden nor in Finland are there any moraines, all the detritus around the great erratics being water-worn; and yet the scratched and polished surfaces, the worn and abrupt sides of the hillocks, in both these countries, resemble precisely the *roches moutonnées* seen in the march of every existing glacier. Agreeing, as I do entirely, with Professor Nördenskiold (for in my published works I have maintained the same view as regards the southern parts of Sweden, and all Northern Russia, Prussia, and Germany),* I also agree with him in the conclusion that the depressions in the surface of Finland, which are now occupied by innumerable lakes, are those which existed when the country was a sea-bottom, and that the present lakes simply occupy the hollows which existed when Finland was raised from beneath the waters. In a table giving the lithological structure of each rock *in situ* which has been grooved, it is shown that the depth of the scratches bears an exact relation to the hardness and resisting nature of the rock. The map—on which

*See "Russia in Europe and the Ural Mountains," vol. i. chapters 20 and 21. Also, "Quart. Jour. Geol. Soc.," vol. ii. p. 349.

every lake and the numerous scratched surfaces are marked, as well as all the altitudes—is a work which must elicit the admiration of every geographer and geologist, and does such honor to Professor Nördenskiold, that our Council has justly placed him in the list of our Honorary Members.

The lines of striation, so carefully laid down by Nördenskiold in Finland, I have myself found extending in the adjacent low regions of Russia, and notably upon the hard quartzose rocks forming the sides of the lake Onega, at a distance of 500 miles from the Bothnia Gulf. There, also, they are seen to be continuous from the shore under the water of the lake, being visible at some feet below the surface. In this flat or slightly undulating country we have all the same proofs as in Finland, that these scratches, groovings, and polishings could only have been produced by stones carried in icebergs; and there, as in Finland, the great erratics, referable to the north-western parts of Norway, have been dropped at numerous intervals, some of them from Lapland, extending to the western flank of the Ural mountains. In the work and map of "Russia and the Ural Mountains," published by myself and companions De Verneuil and Keyserling, the enormous area over which these erratics were transported during the period when the glacial sea covered Russia in Europe and Northern Germany was defined. It was then for the first time made manifest that the currents which transported these blocks had eccentric directions. Thus, whilst the blocks in Finland and Northern Russia had proceeded from N.W. to S.E (having been derived from the old north Norwegian ice-fields), the blocks which covered the plains of Prussia, and extended over Poland up the great valleys, on to the foot of the Carpathians, being also of Scandinavian origin, must have been brought from north to south when all those lands were under the sea. On the east of England the great Scandinavian erratics came from the west coast of Norway, whilst in Lapland, M. Böhtlingk had shown that the blocks were diverted northwards into the icy sea.

These facts of the divergence of the distribution of the erratics, as due to divergent currents, are quite in harmony with what would be found at the present day, if the bottom of the sea could be so laid bare as to enable us to refer to the various north or south polar glaciers, or to those of Greenland, the devious lines of deposit of the blocks derived from each of these regions, as determined by different prevailing currents.

If we refer to what glaciers nave effected upon land, and to those phenomena which could only have been produced when the rocks so affected were submarine, we must admit that two distinct modifications of the same great agency have produced similar results. The great mass of low country in North America, the surface of which has been striated in like manner from north to south, seemed to me long ago to fall into the category of subaqueous striation by floating icebergs, which were here and there arrested in their progress by sunken rocks. When presiding over the Geological Society of London, in 1842, I gave all credit to Mr. Peter Dobson, a citizen of the United States, for the adoption of that view in reference to his native land,—a previous acquaintance with whose writings, I then said, might have saved volumes of disputation on both sides of the Atlantic.* And now, after a lapse of 22 years, I hold to the same belief.

In the admirable work of Sir W. Logan on the "Geology of Canada," my eminent friend expresses the opinion, "that the grooves on the surfaces of the rocks which descend under the water appear to point to glacial action as one of the great causes which have produced these depressions."† Not having visited the region myself, I should have no right to oppose my opinion to that of such weighty authority, were it not that the grounds assigned for believing in the excavating power of glaciers in North America are the same striations on the sides of the lakes, and beneath the water, as those which I have cited from the shores of the Bothnian Gulf and the lake of Onega in Northern Russia. Now, as regards the latter countries, I have shown that land glaciers could never have passed over them; for surely no terrestrial glacier in advancing to Finland and Northern Russia can have scooped out the Bothnian Gulf by the way! Instead of such striation on the sides of rock-basins, now filled with water, being proofs of the grinding and excavating action of former glaciers, particularly in the cases of Finland and North America, where no lofty mountains, as in the Alps, are at hand to give great power to descending masses of ice, I conceive that such phenomena can only be explained by appealing to the grating action of the bottom of former floating icebergs. My belief is, that the great North American lakes were cavities originally due to a combination of ruptures and denudations of the rocks, and that the whole surface of the lower country thus prepared, was under the sea when icebergs coming from Arctic glaciers floated over it.

We can thus well imagine how countless icebergs were here and there arrested on those submarine rocks which now form the sides of the lakes, and how each icy mass, forced on by a powerful current, after producing the well-known striation on the points of stoppage, would necessarily, when set free, float rapidly across the deep sea cavity, until the base of the iceberg was again arrested by the prominences on the opposite side of the depression, there again to make striations with the stones held fast in its bottom. In this

* See "Anniversary Address, Proc. Geol. Soc.," vol. iii. p. 686 *et ante.*

† "Report of Geological Survey of Canada, 1863," p. 889 and note *ib.* Montreal,

way we can just as easily account for the transport of the numerous great erratics which are spread over North America up to 38° N. latitude, as we have explained the transport of the Scandinavian blocks up to the foot of the Carpathian Mountains.

Whilst, therefore, I fully recognize the stupendous spread and influence of former land-glaciers over extensive regions, I at the same time affirm, that as regards the striation and polishing, the worn side and the abrupt side of the rocks affected, floating icebergs, when impeded by submarine obstacles, have also produced those results. The true and independent test of the action of terrestrial glaciers is the existence of moraines. Now, there is no trace of these peculiar accumulations in the South of Sweden and Finland, all the detritus of those regions, as well as of the North of Russia and Germany, being waterworn; and I have yet to learn that there are any evidences of true moraines in the low countries of Canada and the United States.*

P. S.—Whilst I was reading this Address to the Geographers in London, that sound practical geologist, Principal Dawson, was performing a similar duty at the Annual Meeting of the Natural History Society of Montreal. Having received a copy of his Address in time for insertion of a Postscript, I am glad to have the opportunity of stating that he also is a vigorous opponent of the theory which refers the striation of the North American rocks, and the excavation of the great lake basins of that country, to the action of terrestrial glaciers. He shows indeed that the great striation of a large portion of the continent from N.E. to S.W. was from the ocean to the interior, against the slope of the St. Lawrence valley, thus disposing at once of the glacier theory; for it is impossible to imagine that a glacier traveled from the Atlantic up into the interior. Admitting that in limited tracts of Eastern America there may have been local glaciers, Mr. Dawson believes, as I do, that the rocks of the chief count   in question were striated when the land lay beneath the sea.

* For a full explanation of my views respecting the manner in which former floating icebergs transported blocks, and spread out submarine detritus, I must refer the reader to the 21st and 22nd chapters of the work "Russia and the Ural Mountains," pp. 507 to 556. Since that time (1845) I have indeed seen reason to admit a much greater extension of former land-glaciers than my colleagues and myself then believed in, and this I explained in my last Address to the Royal Geographical Society.

IV.

ON THE ORIGIN OF THE SWISS LAKES. BY PROF. B. STUDER OF BERNE.* FROM LON. EDIN. DUB. PHIL. MAG. S. 4, VOL. XXVII, JULY, 1864.

WHEN we reflect upon the origin of the Swiss lakes, we find that it constitutes a problem very difficult of solution, and it is not easy to determine, in the series of geological events, the moment of the formation of the basins which contain them. Eminent geologists, both of Switzerland and of foreign countries, have proposed solutions of this problem; all the forces of nature have been set in action, and nevertheless we appear to be further than ever from its settlement. To be convinced of this, we have only to glance at the excellent summary of the various opinions and of the present state of the question which has just been published by M. de Mortillet.†

The authors may be divided into two classes. Some, amongst whom we find von Buch,‡ F. Hoffman,§ and Ball‖ (according to his remarkable memoir lately published), believe that the same causes which have convulsed the ground in elevating our mountains, have also produced the depressions which separate them. They think that the elevation was accompanied by crevasses of greater or less depth, which have formed our valleys, and that empty spaces were left in the interior, of which the roof has subsequently given way. Lastly, they believe that the basins of our lakes are the remains of these crevasses not yet filled up by the detritus brought down by the rivers. The others, disciples of Buffon, Playfair, and the Wernerian school, ascribe the origin of the valleys and basins to erosion, that is to say, to the destructive action of fluids in motion. These partisans of erosion have quite lately separated again into two classes, being unable to come to an agreement as to the nature of the destructive fluid. Some, following their masters, admit only marine currents, rivers, or torrents;

* Translated by W. S. Dallas, F.L.S., from the *Bibliothèque Universelle*, 1864. *Archives des Sciences*, p. 89.

† *Atti della Soc. Ital.* November, 1863.

‡ *Catal. des Roches de Neuch.* (1804) MS.

§ *Physic. Geogr.* (1837).

‖ Phil. Mag. February 1863.

the others, amongst whom we find some justly celebrated English and Italian physicists and geologists, have lately proposed to accept the intervention of the erosive action of glaciers.

Each of these views is justified by the facts which take place before our eyes, for nature frequently makes use of very different means of producing the same effect. Desor, in an excellent article "On the Physiognomy of the Swiss Lakes"* adopts both the principal theories, and applies them according to the nature of the lake the origin of which he is endeavoring to explain. He distinguishes the *orographic lakes*, or those depending on the orography of the country, from the *lakes of erosion*, of which the basins have been hollowed out by water. The former are divided into three categories: 1st, the lakes of the synclinal or boat-shaped valleys,† such as the Lac du Bourget, the Lac de Joux, and the Lac de Saint-Point; 2nd, the lakes of the isoclinal or combe-like valleys, among which are the lakes of Brienz and Wallenstadt; and 3rd, the lakes of the transverse valleys or *cluses*, of which the lakes of Thun and Uri are examples. The alpine lakes, according to M. Desor, are chiefly orographic lakes; whilst those of Neuchâtel, Bienne, Morat, Zurich, and Constance, and others situated in the lower parts of Switzerland, are lakes of erosion. Some are the combined product of both principles; the Lake of Geneva, from Villeneuve to Vevey, is a transverse-valley lake (*lac de cluse*), and from Vevey to Geneva a lake of erosion. In a supplement,‡ M. Desor extends his classification to the lakes of the Italian slope of the Alps, where he finds, according to M. de Mortillet,§ a new category in the *lakes of moraines*. Their origin is explained by ancient moraines, which have served as barriers to the water at the mouth of the valleys.

The question becomes still more complicated if, in order to determine the epoch of formation of the lakes, we examine the geology of the strata which surround them. All the lower part of Switzerland and of the first chain of the Jura is sprinkled over with Alpine blocks, which, whatever may have been their mode of transport, must necessarily have passed over the lakes in order to pass from their original position to their present place, and we cannot conceive but that the current which carried them would have filled up these basins and formed a great cone of débris at the opening out of the Alpine valleys. This difficulty, against which the genius of von Buch, De Luc, Escher, and others had to struggle during the first and greater part of the present century, has been one of the principal causes of the readiness with which the hypothesis of the

* *Revue Suisse* (1860).

† M. Desor calls these valleys *vallons*, but this term does not appear to be well chosen; *vallon* is the diminutive of *vallée*, and the synclinal valleys, on the contrary, are the largest in the Jura.

‡ *Actes de la Soc. de Lugano*, (1861).

§ *Bull. de la Soc. Géol.* N. S. vol. xvi.

great extension of the ancient glaciers has been welcomed. In this theory, the Alpine blocks have been transported over the depressions between the Alps and the Jura, solidly supported upon ice, instead of being suspended in the air or in water at several thousand feet above the ground. This general coat of ice, which covered all the valleys and all the bottoms, allowed the epoch of the formation of the lakes to remain undecided. They might have been anterior to the glacial epoch, their basins during this period being filled with water or ice; and no one thought it necessary to assume that they were posterior to it, so recent an origin appearing irreconcilable with the evident connection between these basins and the orography of the country.

For a long time, however, there has been known beneath the erratic stratum which accompanies the blocks, a bed of gravel and sand horizontally stratified, and possessing all the characters of a river deposit. This formation, called the *old transported bed* (*terrain de transport ancien*) by Elie de Beaumont, *old alluvium* by Necker, and *diluvium* by recent authors*, is readily distinguished from the erratic stratum which is superimposed upon it. The latter contains a disorderly collection of blocks of all dimensions, and pebbles, frequently striated, in a peculiar mud which is never stratified; whilst in the lower stratum beds or long lenticular accumulations of smooth pebbles, nearly of equal size, alternate or interlock with lenticular or irregular masses of sand, the gravel and sand being either moveable or agglutinated. On examing this gravel of the old alluvium, it is easily seen that its pebbles are, without exception, derived from the Alps or the Subalpine ridges. Like the erratic blocks, they present different characters according to the valley through which they appear to have been conveyed. They correspond with the rocks in position in this valley and its tributary valleys. It is evident that the presence of this ancient alluvium throws us back again into all the difficulties from which we believed ourselves to have escaped by means of the hypothesis respecting the extension of the ancient glaciers; and this hypothesis in this case can no longer render us the same service.

The difficulty may be diminished by reducing as much as possible the mass of the gravels the transportation of which across the lakes, before the great extension of the glaciers, appears to be inevitable. Indeed we know stratified quaternary gravels scarcely distinct from each other in their composition, but which evidently belong to very different ages. In the environs of Lyons and Vienne

*This term should only be applied to the erratic stratum, and it would be better to suppress it altogether. It was introduced, I believe, by Buckland, to designate some recent strata which appeared to him to owe their origin "to a violent and transient flood," and soon afterwards it was extended to nearly the whole of the quaternary strata. I do not know when or by whom this name was applied, in opposition to its etymology and in contradiction to its original signification, to the stratum of ancient alluvium, which bears all the characters of a tranquil deposit from running waters acting through a long series of years.

there are incoherent gravels, identical with some old alluvium, which contain marine fossils, and which M. Lory believes must be united with the Molasse. On the heights of the Albis near Zurich, on other ridges of Eastern Switzerland, and to the north of the Lake of Constance, there are very thick stratified gravels, partly cemented by calcareous tufa, as to the age of which we are in doubt, some regarding them as tertiaries, others as diluvian. On the other hand, in the environs of Berne and Fribourg, and as far as Lausanne, we see the stratum with erratics resting immediately upon the Molasse; the gravels, equal in thickness to the boulder-formation, fill up the depressions beside it, and extend in many places over the boulder-clay. Here, therefore, the gravel is contemporaneous with, or posterior to the glacial epoch, and appears to be the product of the destruction of the erratic deposits by the action of rivers. Lastly, there are large masses of gravel deposited by rivers which have no lakes in their course, such as the Sarine, the two Emmes, and the Thur. In ancient times they appear to have frequently changed their course. Nevertheless, after deducting all these masses, there still remains the true ancient alluvium, forming the base of the erratic deposit; and of this we must endeavor to explain the transportation. This gravel is well developed on the banks of the Adda and the Dora Riparia, in the environs of Geneva, at the mouth of the Kander in the Lake of Thun, in the neighborhood of Uznach, and elsewhere. The horizontal strata of this ancient alluvium rest upon the bevelled edges of the inclined strata of Molasse; the date of their formation must therefore necessarily intervene between the catastrophe which elevated the tertiary beds, and the period of the great extension of the glaciers.

M. de Mortillet* assumes, like M. Desor and the great majority of geologists, that our Alpine lakes are orographic lakes, due to ruptures of the soil which took place when the Alps acquired their present form. He assumes that their basins, before the glacial epoch, were filled with the pebbles and sands which beyond the Alps have also formed the ancient alluvium, and that subsequently, these moveable materials being unable to resist the pressure of the glaciers, the basins were cleared out and filled with ice up to the period of the thaw, and of the retreat of the glaciers into the high Alps. M. Desor† supposes the lakes to have existed until the arrival of the ice, to have been temporarily filled by the glacier which transported the gravel blocks on its surface, and to have returned to the condition of lakes when the glaciers retreated. M. Omboni‡ combines these two solutions in one. The glaciers, according to him, advanced to the lower extremity of the lakes, replacing the water

* *Atti de la Soc. Ital.* vol. v. (1863), November.

† *Revue Suisse*, 1860. *Actes de la Soc. de Lugano*, 1861.

‡ *Atti della Soc. Ital.* vol. v. (1863). November.

with ice; torrents issuing from the long-stationary glaciers deposited the ancient alluvium; and, lastly, the glaciers, again advancing, worked up the soil of this alluvium and deposited the moraines and blocks which repose upon it.

None of these geologists doubted the relation between our lakes and the elevation and orography of the Alps. M. Desor explains even his lakes of erosion by the action of powerful currents caused by the retreat of the waters in consequence of the elevation. The theory was carried still further in England. Mr. Ramsay,* who, from his long-continued researches upon the effects of glacial action in Wales and in the Alps, was prepared to regard the question from a new point of view, sees no essential difference between the small lake-basins of the mountains of Wales, Scotland, and Switzerland, often hollowed out of the solid rock, and the enormous depressions of our great lakes. Attributing the former to the slow erosion of glaciers upon their bottom, he does not hesitate to assume that the same agent has produced the latter, and that all the basins of our great lakes are the result of glacial erosion. As these basins did not exist before the origin of the erratic formation, the transportation of the ancient alluvium by rivers would be explained without any difficulty. This theory of the learned Professor has been favorably received by several geologists of the highest merit. Professor Tyndall† goes still further. He ascribes not only the basins of our lakes, but the Alpine valleys themselves to the erosion of glaciers. The whole Alpine system, according to this celebrated physicist, formed originally an immense smooth boss or enormous mass, in the surface of which the glaciers, by their gradual advance, hollowed out our valleys. Mr. Beete Jukes,‡ who had previously indicated the great effects of erosion in the conformation of Ireland, declares himself in favor of this opinion; and he adds the remark that, according to this theory, the transverse valleys must be more ancient that the longitudinal ones, which explains the bend made by the Rhone at Martigny.

Before seeking for a solution of the problem of the lakes, it appears to be necessary to examine more closely the effects of erosion, which in all the proposed solutions plays an important part. It holds the first place in those of Professors Ramsay and Tyndall, and the second in those of MM. Desor and Mortillet.

No one doubts that erosion has played a great part in the configuration of the valleys and depressions of mountainous countries. When, in our Molassic regions, in Appenzell, in the Emmenthal, and in the neighborhood of Berne, Fribourg, and Lausanne, we see horizontal or slightly inclined strata cut by large and small val-

* Quart. Journ. Geol. Soc. vol. xviii. (1862).

† "Conformation of the Alps," Phil. Mag. September 1862.

‡ Address to the Geological Section of the British Association, Oct. 1862.

leys ramifying into gorges and ravines which date, so to speak, from the last storm,—when in districts in which the ground is schistose, such as the Simmenthal, certain parts of the Grisons or the Valais, or the woodless mountains of Savoy and Dauphiné, we see each fall of rain give rise to new falls of rock,—lastly, when we consider the great masses of débris which from the most remote periods have been transported beyond the mountains by the glaciers and rivers,—it seems impossible to estimate too highly the influence which the constant action of erosion must have exercised upon the conformation of the country. It is certain that many of our valleys owe to it their origin, and nearly all their present characters. Nevertheless there is a limit which the erosive action of rivers and glaciers does not exceed, and which depends upon the resistance of the bottom, the mass of water or ice, and upon the slope. This limit being attained in favor of the resistance, by the solidity of the bottom or by the diminution of the mass of water or of the slope, the rivers, instead of continuing the erosion, fall in cascades and cataracts, or seek issues which present fewer obstacles, or, if their rapidity permits, they form deposits. From time immemorial the falls of the Rhine, the Toccia, and the Aar, and the cataracts of the Rhine at Laufenburg and those of the Danube and the Nile, have not changed either in place or form. When thus we see a river traverse solid rocks, such as compact limestones, granites, or porphyries, whilst at the same level it might have cut itself a way through softer rocks, we must be convinced that its course has not been impressed upon it by erosion. The Rhine near Sargans had to surmount an elevation of only twenty feet above its highest level in order to throw itself in a straight line into the Lake of Wallenstadt; why then should it have taken its course, making a bend and traversing the calcareous mountains of the Schollberg and Fläscher Berg, if these mountains had not offered it a more ready passage, of a different and more ancient origin? Why should the Simme near Wimmis have forced a passage through the limestones of the Burgfluh, when between the latter and the Niesen there were only schists to be traversed? Why should the Sarine have hollowed out its channel by the long limestone defile from Rossinière to Montbovon, when to the left there was the depression of the Mosses, of which the Flysch rock presented much less resistance? The impossibility of explaining by erosion those ravines which are evidently large crevesses, as also the relation existing between the longitudinal valleys and the strike and dip of the strata, are facts long since established in science. They have set up the conviction that the forces of erosion have not acted alone, but that other very powerful agents have modified and fashioned the surface of the globe. It is half a century since this result was indicated in this same journal by a distinguished physicist.* In all treatises on geology the origin of each of the different kinds of valleys is deduced from a particular principle.

The reasons which show us the insufficiency of the erosion by rivers to explain the origin of a great number of valleys, acquire much more force in Mr. Ball's excellent memoir if we apply them to glaciers, the effects of which are comparable to those of streams of lava. If the latter possessed the power of working up the soil over which they pass, which is often composed of movable sand and but slightly coherent tuffs, as it is asserted that the glaciers do, the physiognomy of volcanic cones and districts would be very different from that which we know to belong to them. As in the case of lavas, the retardation of the movements of glaciers upon their bottom is necessarily much greater than with streams of water. Upon the heights, when the mean temperature is below zero (C.), the ice even remains attached to the soil, and the glacier, if it can be formed, only advances at its upper part; but in general the new-fallen snow glides over the solid ice, forming avalanches, and the glacier, remaining unthickened, advances, notwithstanding its often considerable slope, much more slowly than the very large glaciers of the valleys. The latter can hardly exert any very active erosion, their lower surface being often separated from the beds by the water arising from their melting, or by empty spaces, and their movement being far less than that of rivers which appear to us to be stagnant. Nevertheless a certain amount of erosion takes place, as is proved by the turbid water which issues from the glaciers; but its action appears to be limited to rounding off points and salient angles, and polishing and striating the rocks. One of the best ascertained facts is that the erosion of glaciers is distinguished from that of water by the production by the former of convex rocks or *roches moutonnées*, whilst the second gives rise to cavities. The hollows or *marmites* which occur as an exception to this rule in what appears to us to be the rocky bed of ancient glaciers, are justly ascribed to the friction of gravel set in rotation by falls of water through the glacier, or to the *moulins*.

Mr. Ramsay rightly assumes that the basins of our lakes cannot have been hollowed out by running water. A certain incline is necessary to enable rivers, even with a muddy bottom, to hollow out their bed; and this slope does not occur either in the lakes of the Jura or in those of Zurich and Constance. Otherwise, if only a great mass of water were necessary, why do we not find the Nile and the Ganges in their great floods hollowing out basins for themselves? And even if a great inclination be added to the mass of water, and the soil is favorable to erosion, deep holes or *marmites* only are produced, and their extent never exceeds the radius of the

* *Bibl. Brit.* vol. xli.

direct action of the impact of the water and of the pebbles which it sets in motion. Of this we have the proof in our waterfalls, in those of Italy, and in the cataract of Niagara, so well described by M. Desor, as quoted by M. Mortillet. How, moreover, could we suppose that the Rhine, at so great a distance from the high mountains, has had sufficient force to hollow out a basin like that of the Lake of Constance? On the same principle one might suppose the Caspian Sea to be due to the erosion of the Volga, or the Dead Sea to that of the Jordan, and regard these great depressions as mere effects of the erosion of the rivers which traverse them. And if we assume that the basin of the Lake of Constance extended as far as the Schollberg near Sargans, and that it was subsequently filled up by detritus as far as Rheineck, how can we suppose that the same river, which in the first place hollowed out its bed from the Schollberg to Schaffhausen at more than a thousand feet below the present surface of the soil, should have afterwards filled it up? Those who consider that our lakes have been hollowed out by the action of water maintain no such doctrines. M. Desor, as we have seen, requires great floods caused by the upheaval of the Alps; and the celebrated Escher von der Linth*, who knew better than anyone the power of rivers, also calls for the intervention of diluvian waters. It is always the great *débâcle* of De Saussure which, in the theories of its learned author and down to our own day, has played so important a part in the geology of Switzerland. But even if, with the view of increasing the force of the shock, we suppose with von Buch† that the waters of the sea were thrown, by the sudden upheaval of the Alps, over the highest summits, we may still doubt whether they could have acquired and retained the force necessary to hollow out valleys of the depth of our lakes, and of from 20 to 30 Swiss leagues in length.

However, since the appearance of the classical works of Sir Charles Lyell, these great efforts of the imagination are no longer popular, and the great *débâcle*, which was admitted chiefly in order to explain the transportation of boulders, has given place to the calm and slow movement of the glaciers. It is also by means of the glaciers that De Mortillet, Ramsay, and their adherents suppose the basins of the lakes to have been hollowed out. After what has been said as to the erosive action of glaciers, it is useless to return to this question. I shall confine myself to remarking that upon the bed of gravel and detritus of unknown depth which extends in front of our great glaciers at Chamouni, at the glaciers of Arolla, Ferpècle, and the Aar, and in front of all the others, we do not see the least trace of the asserted tendency of the glaciers to bury themselves by dig-

* Gilbert's *Annalen*, vol. liii. (1816).

† Poggendorff's *Annalen*, vol. ix. (1827).

ging out the soil. We also know that in those regions where the glaciers attain the sea-shore, they are prolonged above the water, and do not sink below its level.

Having thus ascertained the insufficiency of erosion for the explanation of the origin of the valleys and lakes of the Alps, we can hardly choose but recognize, with C. Escher, an intimate connection between a great number of Alpine valleys and the inclined position of the strata in the chains which they separate. These are true orographic valleys, such as M. Desor has pointed out in the Jura; and to the two kinds described by him—the *synclinal* and *isoclinal valleys*—we must add, according to Escher, for the Alps, the *anticlinal valleys*, of which the Justithal to the east of the Lake of Thun presents a fine example. As to the *cluses*, with which we shall join those rocky ravines which cut the interior beds of the chains in the direction of the dip, and to which Thurmann has given the name of *Ruz*, these are evidently ruptures, often enlarged by erosion. We shall likewise add the *valleys of sinking* (*vallées d'affaissement*), which indeed do not occur, as far as I know, in the Jura, but play a great part in volcanic countries; and perhaps some flat-bottomed circular valleys in the Alps may be referred to this type.

However, a classification of valleys founded upon the orography of the Jura can only find a very limited application in the Alps. Most of the Alpine valleys, and indeed all those of any extent, are valleys of rupture which cut the strata at more or less oblique angles; frequently also they are complex, and pass from one type to another; and many of them are combined with great faults. Even longitudinal valleys of small size, and apparently quite simple at the first glance, will not conform to the Jurassic classification. The valley of the Bas-Simmenthal may be classed among the synclinal valleys; but what a difference there is between it and the valleys of the same kind in the Jura! At the bottom of the latter the beds are horizontal, and rise to the two sides; in the Simmenthal they are vertical, and diverge upwards like a fan—it looks like a synclinal valley folded up (*refoulée*) by lateral pressure. The valley of the Pays d'Enhaut, from Gessenay to Château d'Oex, also appears to be longitudinal; nevertheless it cuts obliquely through three zones of Flysch and two intermediate ranges of limestone which run from N.E to S.W. The Valais in the neighborhood of Sion is an isoclinal valley, its two sides inclining to the S.E.; but its northern side consists of Jurassic limestone, and the opposite side, which ought to be more recent, belongs to the carboniferous series. Here there has evidently been a great fault. The same circumstance occurs again at the Lake of Brienz: the base of the northern range being Neocomian, the base of the group of the Faulhorn, which would be supposed to be superior, is Jurrassic; and the Neocomian strata only occur at the very summit of this group. The relation of the great transverse valleys of the Alps with the *cluses* of the Jura is no better founded: most of these commence by gigantic *ruz*, such as those of the Aar, of the Grimsel at Gutannen, and of the Reuss from the St. Gothard to Amstæg. Further down this character is lost; the valley, cutting the ranges horizontally, resembles the *cluses*, as that of the Arve from Sallenches to Cluse, that of the Reuss from Amstæg to Brunnen, where it unites with a longitudinal valley, and that of the Aar from Meiringen to Leissigen. But the further we descend, the more we see the difference between its opposite sides increase; so that a valley which still appears to belong to the class of *cluses*, often separates two systems of mountains of a totally different geological character. This is the case in the valley of the Arve between Bronneville and Annemasse, in that of the Aar upon the margins of the Lake of Thun, in that of the Rhine from Scholl-berg to Rheineck, and in that of the Iller at Sonthofen. By this circumstance these valleys acquire a significance of much more importance than that of being simple crevasses; they appear as boundaries, probably of great antiquity, between two different groups of mountains, such as would be a boundary placed between the Alps and the Jura, or between the latter and the Vosges. And, lastly, how are we to class the great semicircular valley which extends from Reichenau by Coire to the Lake of Wallenstadt, resembling, on a colossal scale, the Atrio dei Cavalli of Vesuvius? Moreover, this does not appear to be unique in the Alps. We may find a parallel to it in the valley which follows the Rhone from Martigny to Geneva, and in that which is prolonged from the Lake of Annecy to Faverges. As the latter circle appears to be dependent on Mont Blanc, so that of Eastern Switzerland bounds the spreading foot of the Verrucano of Glaris.

Those valleys which have cracked the Alpine strata are generally regarded as traces of the upheavals, dislocations, and twistings which that country has undergone; and one of the most powerful of these revolutions must be more recent than the Miocene period, as the strata of the Nagelflue and Molasse have been so much affected by it as to have acquired greatly inclined and even vertical positions. On the other hand, we cannot overlook a certain connection between the basins of the lakes and the valleys in which they are situated. These basins appear as the remains of the original depth of the valleys, before their bottoms were partially filled up by rivers. It has always been admitted that originally the basin of the Lake of Geneva extended on one side as far as St. Maurice, and on the other beyond Carouge; it has also been supposed that the two basins of the lakes of Brienz and Thun only formed a single one, which extended upwards as far as Meiringen, and downwards to

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the vicinity of the Belpberg, and perhaps further; and, lastly, that the three lakes of the Jura were not separated as at present by marshes, and that the great basin which contained them must have extended from Entreroches and Payerne as far as below Soleure.

The connection between the basins of the lakes and the tilting of the calcareous and Miocene beds of the Alpine and Jurassic ranges being admitted, we find ourselves face to face with the difficulty already indicated, namely, the transportation of the ancient alluvium beyond the Alps across the lakes; and after having got rid of the proposed solutions, we have only, it seems to me, two ways to escape from this difficulty—two solutions, moreover, which do not mutually exclude each other, and which may be applied according to the configuration presented by the different localities.

We may suppose the deposits of the ancient alluvium to have been produced by rivers which have no lakes to traverse; and these rivers having frequently changed their course, this explanation may be adapted to cases which at the first glance seem to be opposed to it. The beds of sand and gravel which, at the mouth of the Kander in the Lake of Thun, support the moraine of Strätligen, are undoubtedly an ancient deposit of the Kander and the Simme; the great plain between Thun and Thierachern must have had the same origin. All the pebbles on the shore of the lake, as far as the Schadau, are derived from the valleys to the westward of the lake; the ridges of Nagelflue east of the Aar have not furnished a single one. In the same way the position of a great part of the ancient gravels below Geneva is explained by the deposits of the Arve, and a portion of those of the Lake of Zurich by the deposits of the Sihl and the Linth.

I do not, however, conceal from myself that this solution cannot be generally admitted. It does not apply to the ancient alluvia to the south of the lakes of the Italian slope of the Alps; it does not explain the lignitic formation of Uznach, the level of which is considerably above that of the Linth; nor the stratified gravels, older than the glacial deposit, to the north of the Lake of Constance. Even for the Lake of Thun the explanation given does not suffice, inasmuch as we find between Uttigen and Kiesen, two leagues below Thun, vast accumulations of ancient gravel rising to more than 100 feet above the level of the Aar. In these cases we must necessarily have recourse to depressions which have taken place after the deposition of the gravel. M. Guyot* prefers this solution to any other for explaining the origin of the lakes of the Jura, without being driven to it by deposits of ancient alluvium, which do not occur on the left bank of the lakes. In the ridge of Molasse known as the *Molle*, which rises from the bottom of the Lake of Neuchâtel

* *Mém. de Neuchâtel*, vol. iii.

to within 30 feet of the surface of the water, as also in that which, in the Lake of Bienne, unites the Jolimont to the island of St. Pierre, he sees submerged ridges of the same order as those of the valley and the Jolimont still occupying their original position. These sublacustrine ridges, moreover, cannot well accord with the supposition that the lakes had their origin by erosion, whether by means of currents of water or of glaciers, the molasse not being sufficiently solid to resist this.

If we admit the formation of the basins of our lakes by depressions, the deposits of ancient alluvium beyond these basins compel us to assume that the bottom of the great crevasses which form our valleys has been entirely filled up, as is still the case with that of the Arve, that of the Sarine, and others. Although there can have been no deficiency of débris after one of the most terrible convulsions, this filling up undoubtedly requires that an exceedingly long time must have elapsed between the formation of the crevasses and that of the ancient alluvium. Fortunately another consideration, which has nothing hypothetical about it, leads us to the same conclusion, namely, the great difference between the fauna and flora of the last sediments of the Molasse and the first of the ancient alluvium. It requires time, and indeed a long time, to allow a flora analogous to that of the Southern States of North American to give place to that which now grows in our country; and we find the latter represented even in the diluvial lignites. It is probable also that much time would be necessary for the *Anthracotheria*, Tapirs, and Mastodons of the Molasse to yield their place to Elephants, and to Ruminants which appear to be the source of our existing Bovine races. The idea that depressions took place along the lines of the crevasses of the valleys after the latter had been covered by a new soil need not astonish us. Great spaces at the bottom of the fractures may have remained unfilled; narrowings of the rock, or the large size of the first blocks engulfed, may have arrested the filling up of the valley; but subsequently an increase in the weight of this temporary roof, or perhaps the addition of that of the great glaciers of the diluvial period, may have caused the obstacle to yield, and the soil which it supported to fall in.

V.

ON THE ORIGIN OF THE ALPINE LAKES AND VALLEYS. A LETTER ADDRESSED TO SIR RODERICK I. MURCHISON, K.C.B., BY M. ALPHONSE FAVRE, PROFESSOR OF GEOLOGY IN THE ACADEMY OF GENEVA, AND AUTHOR OF THE GEOLOGICAL MAP OF SAVOY.

I AM glad that you have asked my opinion of the new theory, according to which the Alpine lakes have been excavated or scooped out by glaciers; and of that which also explains the origin of the Alpine valleys by means of the erosion produced by glacial action.*

I am a strong partisan of the notion of the transport of erratic blocks by ice, at the period of the great extension of the glaciers, and as a Swiss I am attached to this theory, which is worthy of the term national. But, at the same time that I acknowledge it to be accompanied by certain difficulties, I cannot comprehend the two other theories, although they have the advantage of being advocated by able men of science. Amongst these is to be counted Professor Ramsay, a highly distinguished geologist, to whom long practice on the Geological Survey of England has given great powers of observation and a sure eye (*coup d'œil*), Mons. de Mortillet, who is well acquainted with the Alps, and Professor Tyndall, whose works on physics hold the first place. Not that I do not sincerely respect the opinions of the learned authors who have developed these views, and who have done so, I acknowledge, with considerable ability.

It is evident, indeed, that existing glaciers abrade the rocks on which they move, inasmuch as they polish them. But this action is so feeble, that I cannot see how it has been inferred therefrom that it has been able to scoop out deep lake-basins many hundreds of feet below the mean level of the valleys, even on the supposition that it has been exerted during very long periods. I understand still less how this same action could have excavated valleys many thousands of feet deep in a great rock-mass like that of the Alps.

* A great many arguments against these theories have been advanced in various memoirs, as in those of Mr. Ball (Phil. Mag. 1863, vol. xxv. p. 81). Desor (*Revue Suisse*, 1860), Studer (*Archives des Sc. Phys. et Natur.* 1863, vol. xix.), &c. However unwilling I may be to reproduce the arguments which they have already employed, it is almost impossible not to revert to them occasionally.

A limit must be set to certain effects. This limit exists in all geological questions, and it is indispensable to establish it.

On seeing a dune on the sea-shore, twenty or thirty metres high, formed by means of grains of sand driven by the wind, shall I be right in concluding that in some hundreds of thousands of years this same dune could attain the height of the Alps or that of the Himalaya?

I have no wish to maintain that the glaciers have not exerted any influence on the forms of lakes and valleys. It seems to me to be impossible that masses so considerable as those which moved in the valleys during the glacial epoch, should not have fashioned, more or less, the *borders* of these depressions. But I cannot become an advocate of the belief that glaciers are the original cause of the formation of lake-basins and valleys. I believe both to be a direct consequence of the formation of mountains, and that they both owe their origin to movements of the earth's crust.

Let us now leave these general arguments, and arrive at more precise facts relative to the origin of the Lake of Geneva. According to all glacial theories, the union of all the glaciers of the Valais at Martigny, to a portion of those of the main body (*massif*) of Mont Blanc, formed one enormous glacier, to which the name of the Glacier of the Rhone has been given. This glacier evidently discharged itself into the Swiss plain by the valley which extends from Martigny to Villeneuve, and had a minimum thickness of 2300 to 2600 feet.*

This great glacier extended itself over the plain. It covered all the bottom of the basin of Lake Leman with moraines, boulders, clay, and scratched pebbles. The distribution of these materials has often been studied; they are spread over the two banks of the lake; but I do not think that any conclusion can be drawn from their examination, either for or against the hypothesis which I am desirous of examining.

In the course of its slow but continuous movement, the enormous glacier abutted eventually against the Jura. As M. Charpentier has stated, it is remarkable that the maximum height of the traces which it has left should be near Chasseron, a mountain situated to the north-west of Yverdun, just opposite the valley of the Rhone. The blocks there attain an elevation of 3000 feet above the Lake of Neuchâtel.†

Thence the upper limit of the boulders falls successively towards the north and south, in such a manner that we may apply the term *median* to the line which connects the mouth of the Rhone near

* Charpentier, "Essai sur les Glaciers," pp. 270, 271. I am led to believe that the glacier rose above this limit, and that if blocks are not met with above it, it is owing to their having rolled towards the bottom.

† Charpentier, ibid.

Villeneuve with Chasseron. North of the median line the higher line of the blocks rejoins the plain in the environs of Soleure. The glacier terminates there, and has left at its extreme limit the remarkable blocks of Steinhof, near Soleure. South of the median line the glacier has left incontestable traces over all the southern extremity of the Swiss plain. It has gone beyond the limit of this plain in passing Mont Sion, south of Geneva, and the defile of Fort de l'Ecluse. These facts have long been known; but it is a matter of surprise (reasoning according to the hypothesis of the excavation of the basin of the lake by the glacier) that the lake has not been hollowed out in the direction of the median line—that is to say, from the mouth of the Rhone to Chasseron—but in a curve which bears no relation to that line.

This bend in the lake nearly follows the base of the great mountains which are situated on the southern bank, at least so far as the large lake is concerned. The depth of the basin is evidently connected with the neighborhood of the mountains, and the inclination of the strata; it is thus that near Meillerie, where the mountains are elevated and the strata vertical, the lake attains its maximum depth (265 metres near Meillerie, and 300 metres a little further west).*

Nevertheless it is probable that in this locality the bed of the lake is of the same nature as its banks, that is to say, limestone, and that the ridges there consist of very hard limestone. Further westward, where the lake is situated in Tertiary Mollasse much softer than the limestone, it only attains a depth of from 30 to 40 metres.

This fact is of considerable importance. It seems to me inexplicable, on the supposition that the glacier hollowed out the basin of the lake; on the other hand, it is easy of explanation in connecting the depression of the lake with the inclination of the strata. Near Meillerie the beds of hard limestone are verticle and highly contorted, and there the lake is deep; nearer Geneva the softer beds of Mollasse descend from the two sides of the lake beneath its waters with a gentle inclination, and there the lake is shallower. This proves the relation between the depth of the lake and the flattening of the beds, as has been already stated by M. Studer; and I will show further on, that it is connected with the reversal of the same beds.

Let us now turn to another point.

I consider that the observations made in the neighborhood of Geneva have contributed to the origin of that theory of the erosion of the lakes, which I oppose. These observations may be summed up as follows.

Below the Lake of Geneva there are found considerable accu-

* Chart of the principal soundings of Lake Leman, by H. T. De la Beche, 1827.

mulations formed in their upper part of glacial deposits (clay with scratched pebbles and transported boulders), and in their lower part of the older drift of Necker. This latter deposit is different from the old drift of the greater number of the savants who have written upon the geology of France. We have also in our country this old drift, which is that which I have distinguished in the explanation of my geological map of Savoy by the name of terrace-gravel (*alluvion des terraces*). It contains *Elephas primigenius*. Overlying the glacial drift, this last is higher than the older drift of Necker, upon which I am desirous of making a few remarks. This last is composed of rolled pebbles and sand, often bound together by a calcareous cement. No striated pebbles are seen amongst them. The principal characters of this accumulation in our district consist in its being of older date than the glacial deposit, in being placed below the Lake of Geneva, and in enclosing pebbles (such as those of euphotide) which could not have been derived from the Valais, whence the Rhone glacier proceeded.

These pebbles must consequently have passed over the depressions of the lake. But how could they do so, since their transport appears to be anterior to the development of the glacier? That is the difficulty, and it is this which has given rise to the notion of the theory of excavation, in which it is supposed that the pebbles of the older drift have been heaped up by pre-glacial currents in the depths of the lake, and that when the glacier reached them it excavated that portion of the lake which had been filled up. It is supposed, then, that it has produced a great excavation, and that it then spread before it all this enormous mass of pebbles which it drew from this great depression. This idea, generalized and applied to other localities, has produced the hypothesis which is known by the name of the theory of excavation. I think I have been impartial in this explanation.

To this theory I believe I am able to offer objections which seem to me to be very serious. In the first place, when the glacier originally began to carry away from the depths of the Lake of Geneva all the enormous mass of pebbles which is now deposited lower down, how did it effect it? Did the glacier slide over the solid rock without leaving any intervening mass of these pebbles between the two? For if it left beneath it no pebbles, it ought to push before it an enormous mass of this débris, such a mass as can with difficulty be represented—a mode of action which would be the more singular, because nothing amongst existing causes countenances this supposition, no part of the glacier being seen to push before it an accumulation of *rolled* pebbles. If, on the contrary, the glacier covered these rolled pebbles again, the excavation seems to me to be very difficult, because the glacier moulds itself upon its under surface, and causes the pebbles of the underlying bed of mud to advance very slightly.

Moreover, according to one or the other of these suppositions, I am unable to comprehend how the deposit of older drift could be accumulated below Geneva without any admixture of clay or glacial mud having been produced.

But there is an objection which appears to me to be still more opposed to the theory of excavation.

The supporters of this theory assign to the glacier which formerly invaded our lake a force sufficiently great to enable it to remove, from a depth of 800 metres near Meillerie, all the pebbles of the older drift.* Nearer Geneva the lake is not so deep, and the glacier had still, at this point, the necessary power to scour out of the bed of the lake all those pebbles; for we know that this glacier has extended several leagues further, and that it has passed over Mont Sion and the defile of Fort de l'Ecluse. But about a kilometre below Geneva (at the wood of La Bâtie) the older drift is visible, as I have stated, covered by the glacial deposit over a very large area. At this point one is compelled to conclude that the glacier has not had the power to remove this older drift, and that it has spread itself over it. Is it not evident that the glacier has been supposed to possess immense power above Geneva, and that there is a clear proof that it did not possess that force below the city in question? I believe, then, that the truth lies in the fact that a glacier can slide over a deposit of rolled pebbles without cutting a way through them. Consequently the ancient glaciers have not had the power to remove, near Geneva, the older drift on which they have left their traces, and, for a still greater reason, they have not had the power to remove the rolled pebbles from the bottom of the lake.

The rolled pebbles which constitute the older drift below Geneva, and which are placed beneath the glacial drift, seem to me to have been transported by the torrents which were given out by the glaciers of the Rhone and Arve when they reached the neighborhood of the city. They have been rounded after leaving the glaciers.

This is perceptible below existing glaciers when they reach a plain. In such cases there is nearly always a certain area of deposit occupied by rolled pebbles, which are fashioned, sorted, and levelled by the torrent. The pebbles which form part of the older drift, and which are evidently derived from the Valais, have traversed the depression of the lake when it was filled with ice. They have made the journey in question in the form of erratic blocks or gravel, and were rolled only when they reached the torrent at the base of the glacier.

* Mortillet's Theory.

Subsequently, when this deposit was formed and levelled, the advancing glacier has passed over it; and, on retiring, it has left on its surface the glacial mud, the scratched pebbles and the erratic blocks which we see there even at the present day.

I have endeavored to show that the theory of excavation was insufficient to account for the accumulation of the glacial deposits, and I ground my opinion on the weakness of the excavating power of the glacier, as is proved by the presence of the glacial drift reposing on a light deposit formed of rounded pebbles; for a still stronger reason I cannot believe that a glacier has ever excavated the basin of the lake or a valley. If these depressions had been formed by the glaciers, how shall I explain why there is no lake in the Valley of the Arve, in the valley of Chamouny, or in the Val d'Aoste? The glaciers have, nevertheless, remained for a longer period in those higher valleys, before, during, and after the glacial epoch, than in the valley of the Lake of Geneva.

The valleys of Savoy and the Valais bear a clear relation to the structure of the mountains. They present a remarkable regularity. They are nearly all at right angles to or parallel with the general direction of the Alps. Amongst the former cases is noticed the valley of the Rhone from Martigny to the lake; that of the Dranse, which has its outlet near Thonon; that of the Arve, from Sallanche to Geneva; the valley of Lake Annecy; that of the Isère between Moutier and Albertville, and between Tigne and Bourg St. Maurice, the valley of Chapier, that of Courmayeur, &c. Amongst those which are parallel with the chain of the Alps, are the valley of the Rhone above Martigny, the valley of Chamouny, of the Allée-blanche and Entrèves, the valley of Illiers, the valley of Megève, and that of the Isère below Albertville, and between Bourg St. Maurice and Montiers.

Amongst these may we not reckon the depression in the Lake of Geneva between that town and Rolle, and which is parallel to the great anticlinal axis of the Molasse? This axis extends trom Salève to Lausanne, passing by Boisy, and is continued onwards to Bavaria.* As to the eastern parts of the lake, the direction of which is from west to east, slightly south-east, and which is considered with reason as being partly placed in a depression (*cluse*), it bears a relation to the curved form of the mountains which lie on its southern bank.† To prove this, it is necessary to enter into minute details with regard to the direction of the varicus parts of the chain, which would be out of place here; but I may quote an

* *Bull. Soc. Géol. de France*, 1864, vol. xix. p. 928. *Archives*, 1862, vol. xiv. p. 217.

† It is not on the south bank only of the Lake of Geneva that the chains of mountains assume a circular or semicircular outline. This form is still more developed in the mountains of the left bank of the Arve than in those of the opposite bank. See, in reference to this subject, a note which I have published in the "Reports of the British Association for the Advancement of Science," 1860 (Trans. of Sect., p. 78).

old and classical authority that nobody will call in question, and this quotation will show that the lake presents nearly the form of the mountains. "The ordinary direction of these ranges and of these valleys," says De Saussure,* when speaking of the region lying on the right bank of the Arve (between the Arve and the Rhone), "is nearly that of the entire chain, which in our country extends from the north-east to the south-west. But this general direction varies in some places and undergoes local inflections. One sees from the summit of the Môle that the chains of mountains, which in its neighborhood run nearly north-east, follow for a great distance the curve of the lake, and towards the frontier of the Valais take an easterly direction, as does the lake itself between Rolle and Villeneuve." This form may be recognized in my geological map of Savoy.

These great features, so characteristic of the region of the Alps which border upon us, establish an evident relation between the form and position of the lake-basin, the orography of the ground, and the cause which has elevated the mass of the Alps above the mean level of the continent.

The position of most of the Alpine lakes reveals to us, again, the relation which subsists between the mountains and the lake-basins: nearly all lie either on the borders of the Alps, or at the junction of the beds of Moilasse with hard calcareous chains. They frequently even penetrate the interior of the chains—allowing that the marshes, which are almost always at their upper end, form part of the lakes.

Such are the lakes of Geneva, of Thun, Lucerne, those of Zurich and Wallenstadt (which form only one lake in a geographical point of view), and also the Lake of Constance. In the Bavarian and Austrian Alps, again, are found the lakes of Walchen, Kochel, Schlier, Mond, Atter, Traun, &c., all on the borders of the Alps. Is this very remarkable position the result of chance? or is it not likely that in the law of the structure of the Alps there is a circumstance which has determined the formation of the lake-basins. This had been pointed out by De Saussure when, in describing the mountains lying on the right bank of the valley of the Arve, he remarked that the innermost turned their backs towards the exterior part of the Alps,† but that the outer chains turn their backs to the central chain; that is to say, that their curves are brought up on a line with the Lake of Geneva.

Since the time of De Saussure light has been thrown on the question, and the papers which you yourself have published have contributed largely to the elucidation of this subject.‡ It is now

* Voyages, § 280.

† Voyages, § 281.

‡ Quart. Journ. Geol. Soc. 1848, vol. v pp. 182, 195, 197, 200.

recognized that over the greater part of the enormous distance which separates the environs of Geneva from the eastern Alps of Austria, there is a prolonged reversal of strata, so that very often the older beds repose upon the newer. One can understand that such a great disturbance in the strata should have produced a subsidence in those which are beneath the surface by a sort of reciprocating movement (*bascule*). As regards the Lake of Geneva in particular, this reversal has been clearly pointed out on the two banks—on the northern at Playaux near Vevey, and on the southern at Voirons, east of Geneva. These two mountains are both situated on the borders of the Alpine chain. In order properly to grasp the relation which subsists between the overthrow of the strata along this line and the great depths of the lake, it is necessary to mark on the map the soundings of the lake by De la Beche, the positions of the crests of the Voirons, the Allinges south of Thonon, and of Playaux near Vevey.*

The principal soundings of the lake placed opposite Meillerie and Evian may likewise (and perhaps it is the most easily effected) be marked on the geological map of Savoy. Then Voirons and Playaux should be joined by a line (but not by a straight line, because the chains on the borders of the lake are curved) drawn through Calvaire (Voirons), Allinges, the point where the Alpine Macigno (M) (Affleure) descends to a level with the bed of the Dranse, at a distance of four kilometres from Thonon and the city of Evian. Such a line as this would terminate towards Playaux, passing over the northern bank of the lake between Corsier and St. Saphorin.

This course shows pretty nearly the line of the reversal of the strata situated on the flanks of the Alps; and, presenting a certain parallelism to the denudations of the different rocks traced on my geological map of Savoy, it passes through the midst of the soundings which indicate the greatest depth of the lake. Consequently this depth bears a relation to the reversal of the beds. *It is in such fractures, I am confident, that the true cause of the origin of these lake-basins is to be found.*

From a summary of these facts it may be concluded—

1st. That the Lake of Geneva deviates much from the median (central) line of the great glacier or glaciers which extended from the Rhone to the Jura.

2ndly. That these ancient glaciers not having had the power to remove the older drift below Geneva, have not been able to produce in the lake-basins what is called their excavation (*l'affouille-*

* This mountain, called Pleyaux or Playaux, is indicated on the Federal map by the name of Pléiades. To facilitate the indication of it on my geological map of Savoy, on which it is not marked, I should say that it lies 6 kilometres from the mouth of the stream which discharges itself into the lake between Vevey and Corsier, and 6½ kilometres from the point of Montreux.

ment). If they could not scoop out these basins, still less have they excavated the adjacent valleys which terminate in them.

3rdly. The valleys and the basins of mountain-regions are related to the cause which has given to the mountains their orographical characters, and to the strata their greater or less inclination.

4thly. We have seen, in fact, that, so far as the Alpine lakes generally are concerned, and as regards that of Geneva in particular, their position has been determined along a line of overthow, or reversal of the strata. We have seen that the form of the Lake of Geneva was caused, in the eastern part, by the curvature of the mountains on its southern banks, and in its western part by its parallelism with the great anticlinal axis which traverses Switzerland.

Finally, we have remarked that the greatest depth of the Lake of Geneva lies along the line of reversed strata which occurs at the junction of the Alps with the plain. Consequently the sort of basin to which this lake belongs is not the result of a cause acting on the surface of the globe, but is what may be termed a volcanic effect (that word being used in the sense assigned to it by Humboldt), viz. the influence exerted by the interior forces of a planet on its external crust in the different stages of its cooling. Accept, &c. &c.,

ALPHONSE FAVRE.

P. S.—Since the dispatch of my previous letter, I have read with extreme interest your Address to the Geographical Society of London, of the 23rd May, 1864, with which you have been so good as to favor me. I find in that address a clear and precise summary of the state of the question, and valuable evidences derived from many parts of the world. I perceive in it, again, with pleasure that we are of the same opinion respecting the excavation of lakes and the erosion of valleys by glaciers. You make use of several highly important arguments against that view of the question, and you have already developed the idea on which I have dwelt—viz., that the form of the Lake of Geneva is divergent from the direction of the most powerful or central portion of the glacier of the Rhone, which advanced from the Valais in the direction of Yverdun, following what I have termed the median line.

Pray, Sir, oblige me by inserting this remark at the end of my letter of the 12th of January.—A. F.

Geneva, January, 1865.

VI.

THE ANCIENT GLACIERS OF AOSTA, ETC. FROM SCRAMBLES AMONGST THE ALPS.* BY EDWARD WHYMPER.

AT some very remote period the Valley of Aosta was occupied by a vast glacier, which flowed down its entire length from Mont Blanc to the plain of Piedmont, remained stationary, or nearly so, at its mouth for many centuries, and deposited there enormous masses of débris. The length of this glacier exceeded 80 miles, and it drained a basin 25 to 35 miles across, bounded by the highest mountains in the Alps. It did not fill this basin. Neither the main stream nor its tributaries completely covered up the valleys down which they flowed. The great peaks still rose several thousand feet above the glaciers, and then, as now, shattered by sun and frost, poured down their showers of rocks and stones, in witness of which there are the immense piles of angular fragments that constitute the moraines of Ivrea.† The wine which is drunk in that town is produced from soil that was borne by this great glacier from the slopes of Monte Rosa; and boulders from Mont Blanc are spread over the country between that town and the Po, supplying excellent materials for building purposes, which were known to the Romans, who employed them in some of their erections at Santhia.‡

The moraines around Ivrea are of extraordinary dimensions. That which was the lateral moraine of the left bank of the glacier is about *thirteen miles* long, and, in some places, rises to a height of 2130 feet above the floor of the valley! Professor Martins terms it "la plus elevée, la plus régulière, et la mieux caractérisée des Alpes."§ It is locally called *la Serra.* The lateral moraine of the right bank also rises to a height of 1000 feet, and would be deemed enormous but for the proximity of its greater comrade; while the terminal moraines cover something like twenty square miles of country.

The erratic nature of the materials of these great rubbish-heaps was distinctly pointed out by De Saussure (*Voyages,* §§ 974–978);

* Chap. xvi. pp. 341–344.

† See General Map.

‡ I am indebted for this fact to Professor Gastaldi.

§ *Revue des Deux Mondes.*

their true origin was subsequently indicated by Messrs. Studer (1844) and Guyot (1847); and the excellent account of them which has recently been published by Professors Martins and Gastaldi leaves nothing to be desired either in accuracy or completeness.* It is not my purpose, therefore, to enter into a description of them, but only to discuss some considerations arising out of the facts which have been already mentioned.

It has been proved beyond doubt that these gigantic mounds around Ivrea are actually the moraines of a glacier (now extinct) which occupied the Valley of Aosta; and it is indisputable that there are boulders from Mont Blanc amongst them. The former facts certify that the glacier was of enormous size, and the latter that it must have existed for a prodigious length of time.

The height of *la Serra* indicates the *depth* of the glacier. It does not fix the depth absolutely, inasmuch as its crest must have been degraded during the thousands of years which have elapsed since the retreat of the ice; and, further, it is possible that some portions of the surface of the glacier may have been considerably elevated above the moraine when it was at its maximum altitude. Anyhow, at the mouth of the Valley of Aosta, the thickness of the glacier must have been at least 2000 feet, and its width, at that part, five miles and a quarter.

The boulders from Mont Blanc, upon the plain below Ivrea, assure us that the glacier which transported them existed for a prodigious length of time. Their present distance from the cliffs from which they were derived is about 420,000 feet, and if we assume that they traveled at the rate of 400 feet per annum, their journey must have occupied them no less than 1055 years! In all probability they did not travel so fast. But even if they were to be credited with a quicker rate of motion, the length of time which their journey must have taken will be sufficient for my purposes.†

The space of 1055 years, however, by no means represents the duration of the life of the glacier of Aosta. It may have existed for immense periods both anterior and posterior to the journeys of

* *Essai sur les terrains superficiels de la Vallée du Po*, extrait du Bulletin de la Société Géologique de France, 1850.

† See Forbes' *Occasional Papers on the Theory of Glaciers*, pp. 193–95, and *Travels through the Alps of Savoy*, 2nd ed. pp. 86–7, for information bearing upon the mean annual motion of existing Alpine glaciers. In the former work an account is given of the discovery of the remains of a knapsack ten years after it had been dropped in a crevasse, at a horizontal distance of 4300 feet from the place at which it had been lost, showing an average annual motion of 430 feet. In the latter work there is a relation of the recovery of the remains of a ladder used by De Saussure, which had travelled about 13,000 feet in 44 years, or 295 feet per annum. Forbes says that the first of these two examples is better ascertained in all its particulars than the other. It should be observed that the knapsack in question mado the descent of the well-known "ice-fall" of the Glacier de Talèfre and that there was a difference of level between the place at which it was lost and that at which it was found of 1145 feet; that is to say, it descended one foot in every four that it advanced. This rapid descent undoubtedly accelerates the motion of the Glacier de Talèfre. The town of Ivrea, on the other hand, is 768 feet (Ball) above the level of the sea, while Entrèves (at the foot of Mont Blanc) is 4216 feet (Miculet). So that the glacier which once spread over the sites of these two places (which are about 65 miles apart) descended by an average gradient of almost exactly 1 in 100. This moderate rate of inclination would as certainly tend to retard the motion of the glacier.

the Mont Blanc boulders. The frontal terminal moraines, which stretch from Caluso to Viverone (a distance of more than ten miles), are evidence that the snout of the glacier remained stationary, or nearly so, for a length of time which must at least be estimated by centuries, and probably extended over thousands of years. These moraines constitute important chains of hills whose bases are several miles across, and which attain a height of more than a thousand feet; and, as they were formed by the gradual and slow spreading out of the medial and lateral moraines, it is evident that they were not built up in a day.

Moreover, when the glacier of Aosta shrank away from Ivrea, its retrogression may have been comparatively rapid, or it may have been conducted with extreme deliberation. But, under any circumstances, the extinction of such a tremendous body of ice must have extended over many years, and for a portion of that time a large part of the mass must have been advancing down the valley, although the snout of the glacier was retreating, and although the entire mass was diminishing in volume. If the time is considered which was consumed during this phase of its life, and the time which elapsed during its prolonged sojourn at Ivrea, and the time which passed before it attained its maximum dimensions, it must be conceded that the period of 1055 years was, in all probability, only a *small* portion of the epoch during which the Valley of Aosta sustained the grinding of this enormous mass of ice.

Let us confine ourselves to certainties. Here, then, was a glacier which flowed down the Valley of Aosta for more than a thousand years, having a thickness of 2000 feet,* a width of several miles, and a length of eighty miles. The existing glaciers of the Alps do not approach these dimensions, and even in the period when the ice-streams of Europe had so great an extension there were very few which surpassed them. Still fewer, perhaps, existed for so long a period, and there are probably only one or two—such as the ancient glacier of the Rhone—which have received as much attention and have been as carefully studied. For these reasons it seems to me to be more advantageous to refer to it than to instances more imperfectly known and more open to doubt; and I have selected it, on account of these reasons, as a valley which should afford strong testimony in support of the theories which assert that the valleys and many of the lake-basins of the Alps have been excavated by glaciers.

The latter of these two theories was communicated to the Geological Society, by Professor Ramsay, on March 5, 1862.† It

* This is understating the case. The thickness of the glacier exceeded 2000 feet at the *mouth* of the valley, where it had a width of 5½ miles. In the valley itself, where the width was less, the thickness appears to have been considerably more than 2000 feet.

† Professor Ramsay's paper was printed in the *Quarterly Journal Geol. Soc.*, August 1862. The germs of the Professor's theory are to be found in his *Old Glaciers of Switzerland and North Wales*, 1860, pp. 86, 107, 109, 110.

received much attention, and excited much criticism. I am not aware that Professor Ramsay replied to any of his critics, excepting Sir Roderick Murchison and Sir Charles Lyell. But in answer to the objections which were raised against the reception of his theory by these distinguished geologists, he published two papers in the *Philosophical Magazine* ;* and, in endeavoring to present my reader with a *résumé* of the Professor's views, I shall draw from these papers as freely as from his original memoir, for they afford amplification and elucidation of his argument.†

Professor Ramsay said, in opening his case, "There is no point in physical geography more difficult to account for than the origin of most lakes. When thought about at all, it is easy to see that lakes are the result of the formation of hollows, a great proportion of which are true *rock-basins*, that is to say, in hollows entirely surrounded by solid rocks, the waters not being retained by loose detritus."‡ It is in reference to such ones alone that his theory was propounded. He then went on to state, in especial reference to lakes of this class in the Alps—

§ 1. "That the theory of an area of *special subsidence* for each lake is untenable.

§ 2. That none of them lie in lines of *gaping fracture* (rents and fissures).

§ 3. That none of them occupy simple synclinal basins formed by the mere disturbance of the strata after the close of the Miocene epoch."§

And he therefore argued that they must have been produced by erosion ; but

§ 4. They do not lie in hollows of common watery erosion, nor can they be effects of marine denudation.

He consequently concluded, "If we have disposed of these hypotheses for the formation of such hollows, what is left?

§ 5. The only remaining agent is the denuding power of ice."||

He then proved that, in the Alps and elsewhere,

§ 6. "Each of the lakes lies in an area once covered by a vast glacier."¶

And went on to reason—

§ 7. "If a glacier can round, polish, and cover with striations the rocks over which it passes—if, flowing from its caverns, it can charge rivers thickly with the finest mud, then it can wear away its rocky floor and sides."**

* October 1864, and April 1865.

† I shall also occasionally refer to his *Physical Geology and Geography of Great Britain*, and to *Old Glaciers of Switzerland*, etc.

‡ *Physical Geology and Geography of Great Britain*, p. 86.

§ *Proc. Geol. Soc.*, Aug. 1862, p. 200.

|| *Physical Geology and Geography*, p. 88.

¶ *Proc. Geol. Soc.*, p. 199.

** *Phil. Mag.*, October 1864, p. 303.

§ 8. He assumed that glaciers are competent to produce lake-basins, and that they have done so by scooping out softer parts of the country, leaving hollows surrounded by a framework of harder rocks; "but perhaps more generally they (the rock-basins) were formed by the greater thickness and weight, and consequently proportionally greater grinding pressure of glacier-ice in particular areas,"* "the situations of which may have been determined by accidental circumstances, the clue to which is lost, from our inability perfectly to reconstruct the original forms of the glaciers."† The particular manner in which he supposed the great lake-basins of the Alps were formed was as follows:—

§ 9. "It will be evident that when the general inclination of a valley was comparatively steep, a glacier could have had no opportunity of cutting for itself any special basin-shaped hollows. Its course, with a difference, is like that of a torrent. But in a flat-bottomed part of a valley, or in a comparative plain that lies at the base of a mountain range, the case is not the same. For instance, to take an extreme case, if a glacier tumble over a slope of 45°, no one would dream of the ice-flow producing any special effect, except that in the long run, the upper edge of the rock that forms the cataract being worn away, its average angle would be lowered. And so of minor slopes; if the ice flowing fast (for a glacier) rendered the rocky surface underneath unequal, such inequalities could not become great and permanent; for the rapidly-flowing ice would attack the projecting parts with greater power and effect than the minor hollows, and so preserve an approximate uniformity, or an average angle of moderate inclination. But when a monstrous glacier descended into a comparative plain, or into a low flat valley, the case was different. There, to use homely phrases, the ice had time to select soft places for excavation, and there, if from the confluence of large glaciers, or for other reasons, the downward pressure of the ice was of extra amount, the excavating effect, I contend, must have been unusually great in special areas, and have resulted in the formation of rock-bound hollows."‡

He accounted for the deep parts of the lakes by supposing that—

§ 10. "The grinding action lasted after a glacier had retired above the position of the present lake-barrier, so that the waste of the rocky floor being long continued, by degrees the glacier wore out a depression deeper and deeper, till, on its final retirement, the space once occupied by ice became filled with the water drainage of the valley."§

* *Proc. Geol. Soc.*, 1862, p. 188.

† *Ibid.* p. 200.

‡ *Phil. Mag.*, October 1864, p. 305.

§ *Old Glaciers*, pp. 104–5.

The shallowness at their mouths was thus explained:—

§ 11. As the glaciers "progressed and melted, the ice must have been thinner, and must have exercised less erosive power than where it was thick, whence the gradual slope of the bottom of these lakes towards their outflows."*

§ 12. "Therefore I have been forced to the conclusion, from a critical examination of many of the lakes in and around the Alps, that their basins were scooped out by the great glaciers of the glacial period."†

The astonishment which Professor Ramsay's theory created had not subsided when Professor Tyndall brought forward opinions of an even bolder character,‡ and avowed his belief that the *valleys* of the Alps had been (entirely?) excavated by glaciers! His summing up was as follows:—

> "That such an agent was competent to plough out the Alpine valleys cannot, I think, be doubted; while the fact that during the ages which have elapsed since its disappearance the ordinary denuding action of the atmosphere has been unable, in most cases, to obliterate even the superficial traces of the glaciers, suggests the incompetence of that action to produce the same effect. That the glaciers have been the real excavators seems to me far more probable than the supposition that they merely filled valleys which had been previously formed by water denudation. Indeed the choice lies between these two suppositions: shall we assume that glaciers filled valleys which were previously formed by what would undoubtedly be a weaker agent? or shall we conclude that they have been the excavators which have furrowed the uplifted land with the valleys which now intersect it? I do not hesitate to accept the latter view."—*Phil. Mag.*, Sept. 1862, p. 172.

Except for the character of the magazine in which Dr. Tyndall's paper appeared, it might have been supposed that he was poking fun at his readers and at Professor Ramsay. For although to some persons he might have seemed to be supporting the views of the Professor, he was, in reality, advancing opinions which were directly opposed to them. Professor Ramsay promptly repudiated this doubtful extension of his theory. Indeed, he could hardly do otherwise, after having spoken of "the well-ascertained fact, that *previous to the Tertiary glacial epoch*, most of the grander contours of hill and valley were in Britain (and elsewhere in Europe and America), *nearly the same as now.*" He now repeated the same statement in slightly different words. "The evidence is imperfect; but such as it is, it gives much more than a hint that the large valleys were in their main features approximately as deep as now, before they were filled with ice;"§ and, further, he produced in evidence a potent reason for declining to believe that the Valley of

* *Phil. Mag.*, April 1865, p. 298.
† *Phys. Geol. and Geog.* p. 90.
‡ *Phil. Mag.* Sept. 1862.
§ *Phil. Mag.* Nov. 1862, p. 379.

Aosta had been excavated by glaciers. This latter passage will presently be quoted at length, on account of its importance.

For a time Dr. Tyndall made no sign in reply, but, in October 1864, he communicated another paper to the *Philosophical Magazine*, in which he modified his views to a certain extent (and made the important admission that it was perhaps impossible to say whether water or ice had produced the greatest amount of erosion), although upon the whole he adhered to his former assertions. This paper contained one remarkable passage; remarkable, because it partly showed the workings of its author's mind, and because it was, apparently, intended to controvert Professor Ramsay's theory. It was as follows:—

"On the higher slopes and plateaus—in the region of cols—the power (of glaciers) is not fully developed; but lower down tributaries unite, erosion is carried on with increased vigor, and the excavation gradually reaches a maximum. Lower still the elevations diminish and the slopes become more gentle; the cutting power gradually relaxes, and *finally the eroding agent quits the mountains altogether, and the grand effects which it produced in the earlier portions of its course entirely disappear.*"*—*Phil. Mag.*, Oct. 1864, p. 264.

That is to say, precisely in the situations where Professer Ramsay required glaciers to produce the greatest effects, Dr. Tyndall asserted they produced none whatever! Professor Ramsay did not allow much time to elapse before he contradicted these statements categorically.

"Every physicist," said he, "knows that when such a body as glacier-ice descends a slope, the direct vertical pressure of the ice will be proportional to its thickness and weight and the angle of the slope over which it flows. If the angle be 5°, the weight and erosive power of a given thickness of ice will be so much, if 10° so much less, if 20° less still, till at length, if we may imagine the fall to be over a vertical wall of rock, the pressure against the wall (except accidentally) will be *nil*. *But when the same vast body of ice has reached the plain*, then motion and erosion would cease, were it not for pressure from behind (excepting what little motion forward and sideways might be due to its own weight). This pressure, however, must have been constant as long as supplies of snow fell on the mountains, and therefore the inert mass in the plain was constantly urged onwards; and because of its vertical pressure *its direct erosive power would necessarily be proportional to its thickness, and greater than when it lay on a slope;* for it would grate across the rocks, as it were, unwillingly and by compulsion, instead of finding its way onwards more or less by virtue of gravity. *Indeed the idea is forced on the mind, that the sluggish ice would have a tendency to heap itself up just outside the mouth of the valley, and there attain an unusual thickness, thus exercising, after its descent, an extra erosive power.*"†—*Phil. Mag.*, April 1865, p. 287.

Professor Tyndall does not appear to have found the reply convincing. He is reported to have said at the last Birmingham meeting of the British Association, "that he was convinced that the glaciers of the Alps were competent to scoop out the valleys of the

* The italics are not in the original.

† Comparison of the sentences placed in italics, with the preceding one from **Dr. Tyndall**, will show how irreconcilable were the opinions of these two writers.

Alps,"* and I am unaware that his opinions have undergone any alteration since that time. In 1869 he gave a hard side-blow to Professor Ramsay, in *Macmillan's Magazine*, by proving that some existing Alpine glaciers exercise little or no erosion upon their beds near and at their terminations (snouts), because at such places they are *almost stationary*.†

It is impossible to criticise these two theories at the same moment. Both of them agree in attributing enormous powers of excavation to glaciers, but they disagree totally and completely as to the *modus operandi* by which the effects were produced. They differ even in their general conclusions. One asserts that the greatest effects were produced upon the plains, and that very little was done amongst the mountains; whilst the other declares that the mountains owe their actual forms to the carving of glaciers, and that the plains did not suffer at all! There is no wonder that the unenlightened public enquired, "Who shall decide between the disagreements of these doctors?" But it *is* surprising to find numerous persons accepting as gospel truth the contradictory *dicta* of these eminent men, and speaking and writing as if it were established that lake-basins and mountain-valleys have been excavated by glaciers.

It is not requisite to decide between all the differences contained in these two theories, in order to arrive at a tolerably correct judgment upon the general conclusions. Professor Ramsay, for example, attributes the production of the greatest effects to the *weight* of glaciers. Professor Tyndall, on the other hand, assigns most power to the *motion*. I shall ignore these points, because I have no data from which to arrive at a satisfactory decision, and because it is not necessary for them to be mixed up with a discussion of the question, Were the valleys of the Alps excavated by glaciers? For the consideration of this subject, let us now return to the Valley of Aosta.

The town of Ivrea is placed at the mouth of, but not actually within the valley, and several miles of flat, dusty road have to be traversed before it is entered. Upon this portion of the country civilization is doing its best to efface the traces of the glacial period. Cultivation of the soil disturbs all deposits, and the hammers of the masons destroy the erratics. After quitting Ivrea, almost the first object of interest is the castle of Montalto, perched on a commanding crag, nearly in the centre of the valley. Thence, from Settimo Vittone up to the foot of the existing glaciers of the range of Mont Blanc, there are traces of glacier-action upon each hand. The road

* *Birmingham Daily Post*, September 13, 1865.

† It must not be understood that anything of the nature of a controversy was carried on, in the magazines cited, by the two Professors. They did not refer to each other by name; but it was impossible to read the passages which have been quoted, without feeling that they were intended to be replies to objections on the other side.

need not be quitted to seek for them;—they are *everywhere.* I refer especially to the rocks *in situ.* The rock-forms called *roches moutonnées* are universally distributed, and it is needless, at the present moment, to point to any in particular. Although of varying degrees of resistancy, they have, upon the whole, stood the weathering remarkably well of the thousands of years which have elapsed since the glacier covered them. The floor of the valley, generally speaking, has not been lowered since that time, by the combined agencies of sun, frost, and water, to any appreciable extent. The forms which the *roches moutonnées* present to-day, are the forms which they presented, perhaps, ten thousand years ago. Many of those which are *freely* exposed to the atmosphere retain a high polish and fine striations. If the soil were to be removed that covers the flatter portions of the valley, we should doubtless find *higher* polish, and still *finer* striations. Nevertheless, those which are visible remain so perfect, that it is certain weathering has done exceedingly little to alter their contours, and we may argue regarding them as if their icy covering had been but just removed. This point is of no small importance; and, it seems to me, it may be demonstrated from the very contours of these glaciated rocks, that the valley was *not* excavated by glaciers, and indeed, that it was eroded by glaciers only to a very limited extent.

For the forms which are called *moutonnées* preponderate very largely. The rocks which I have ventured to term *roches nivelées*, are comparatively rare,* although they are sufficiently numerous to show that the valley was subjected to severe grinding for a great length of time. They are found upon the floor of the valley, or in places where it narrows, or upon the lower sides of little ravines (now watercourses) which the glacier had to cross, into which it was forced down when in the act of crossing, and out of which it escaped by mounting the opposite bank. In brief, they are found precisely where they should be found. In those places where the thickness of the ice was greatest, and where the motion was (probably) quickest; where the glacier was compressed laterally, so that its power was distributed over a smaller area of rock-surface; and where erosion had produced ruts into which the glacier was pressed down, and out of which it could only extricate itself by a severe struggle.

Throughout the valley, in conjunction with the *roches moutonnées*, there are innumerable *angular rock-surfaces* which seem never to have been abraded by glacier. These *lee-sides*† are found right up to the bases of the existing glaciers. That is to say, they are found in spots which were not only covered by ice during the whole of the period in which the ancient glacier of Aosta extended to Ivrea, but have been covered by it in quite recent times. Glacier moved over them, probably, ages before the great glacier filled the valley; and, for aught we know to the contrary, it has done the same almost ever since. Yet, to all appearance, ice has never *touched* the *lee-sides*, or, if it has done so, it has been done so tenderly, that the marks have been subsequently obliterated.

Now, whilst it may readily be admitted that atmospheric action is capable of completely effacing feeble traces of glacier-erosion,* we cannot in the present instances admit any more. The contiguous surfaces to the *lee-sides*, which are highly polished and bearing fine striations, show that sun, frost, and water have done very little upon them since the ice departed. It would be absurd to suppose that these powers have been able to rub out *all* traces of ice-action (if the traces were other than very feeble) in one square yard, when in the next, upon the same rock, they have been unable even to roughen the surface, or get rid of fine scratches. It is doubly impossible to suppose that the rock-surfaces were uniformly ground down by ice, and that all the inequalities seen at the present time are the result of subsequent decomposition. I do not think any one will have the hardihood to assert the contrary.

It is stated, therefore—1. That the glacier-eroded rocks in the Valley of Aosta are chiefly characterized by *convexity*, and principally belong to the class termed *moutonnées*. 2. That there are examples of *roches nivelées* in the valley; that they are rare in comparison with the *roches moutonnées*; and that they are mostly found upon the floor of the valley, or in places where it is narrowest, or where unusual obstructions have occurred. 3. That there are innumerable angular rock-surfaces (intermingled with these glaciated surfaces upon the floor and on the sides of the valley) which cannot have been produced since glacier covered the rocks. For the bearing of these facts upon Dr. Tyndall's theory, I must now recapitulate from Chapter VI.

In the preliminary remarks at pp. 142–3, after appealing to Studer's observation that glacier-erosion was distinguished by the production of convex forms, I proceeded to show that such forms naturally resulted from glacier working upon surfaces which had been antecedently broken up by diverse actions; and pointed out that when glacier-action was long continued, the obliteration of all angular surfaces, and of almost all curves, was inevitable. I concluded, therefore (and am prepared to accept all the responsibility which attaches to the conclusion), that the convexity of *roches moutonnées* was to be regarded as a proof that no great amount of glacier-erosion had occurred; that rock-surfaces with a *small* degree of

* Or, given sufficient time, of destroying highly-glaciated surfaces.

convexity, which had obviously been glaciated, indicated a *greater* erosion; and that the degree of flatness bore a direct relation to the amount of power which has been employed. And further, that when unworn, angular rock-surfaces were found in the immediate vicinity of glaciated rocks, they were to be regarded as additional and confirmatory evidence that the depth of matter taken away by the glacier could not have been important, unless it could be shown that the angularity was due to subsequent operations.

Applying these conclusions to the case of the Valley of Aosta, we find—1. That as recent denudation has been unequal, throughout the valley, to obliterate polish and fine striations on the rocks, we are unable to believe that the vast numbers of angular surfaces which are found in contiguity to the abraded ones can possibly have been produced subsequently to the retreat of the glacier. 2. Their existence in connection with innumerable convex glaciated surfaces throughout the valley, is irrefutable evidence that the valley was not excavated by glaciers. 3. The comparative scarcity of *roches nivelées*, combined with the other evidence, affords a strong presumption that the so-called *excavation* has not amounted, throughout the valley, to more than a very few feet of depth.

Hitherto, I have chiefly appealed to the bed (or floor) of the valley. Almost equally stubborn facts are obtainable from the slopes of its bounding mountains. If the valley had been excavated by glaciers, very emphatic traces would have been left behind *everywhere—above* as well as *below*. I contend that if the entire valley had been excavated by glaciers, the surface of the rocks would have been as smooth as glass, from one end to the other, when the ice retired. Now, I have frankly admitted (note to p. 114) that, given sufficient time, sun, frost, and water, are capable of destroying highly glaciated surfaces; but I will not admit the possibility of such perfection of glaciation as I have just indicated being completely effaced (say, at heights exceeding 9000 feet), while a few yards lower down ice-marks are seen, and seen everywhere. For it is well known to all who have scrambled amongst the Alps, that those mountains are not glaciated from summit to base. The marks of the great glaciers of the olden time extend up to a certain height, and then they cease. This is the case throughout the Alps generally. The limit of glaciation is usually placed at about 9000 feet. Above this limit the mountains are more or less rugged and angular. Below it, the traces of the glacial period are more or less apparent. Above it you seek in vain for glacier-eroded rocks.*

† It is not, of course, meant that there are no traces of glacier-action above 9000 feet, upon rocks bounding, or surrounded by, the *existing* glaciers. There are, for example, many islands of rock in the Alps, surrounded by glacier, at elevations considerably exceeding 9000 feet, which are highly glaciated. I refer to those mountains which are away from the existing glaciers, and which have never been influenced by them.

Below it, they are found almost everywhere. Here is the evidence of Agassiz upon this point :—

"Every mountain-side in the Alps is inscribed with these ancient characters, recording the level of the ice in past times. . . . Thousands of feet above the present level of the glacier, far up towards their summits, we find the sides of the mountains furrowed, scratched, and polished, in exactly the same manner as the surfaces over which the glaciers pass at present. These marks are as legible and clear to one who is familiar with glacial traces as are hieroglyphics to the Egyptian scholar; indeed, more so,—for he not only recognizes their presence, but reads their meaning at a glance. *Above the line at which these indications cease, the edges of the rocks are sharp and angular, the surface of the mountain rough, unpolished, and absolutely devoid of all those marks resulting from glacial action.** On the Alps these traces are visible to a height of nine thousand feet."—*Atlantic Monthly*, Feb. 1864.

If these facts mean anything, they mean that the great glaciers of the glacial period did not extend above this limit. For I cannot suppose that Dr. Tyndall is a believer in the childish notion of the late Dollfus-Ausset, that glaciers are, and were, permanently frozen to the rocks at heights exceeding 9000 feet, and therefore do not, and did not, erode them!† If that idea is correct, why are there any crevasses at heights exceeding 9000 feet? In what manner is the continuity of the glaciers maintained, if their lower portions move down, whilst their upper ones are immovable? Dr. Tyndall is far too well acquainted with glaciers to believe any such absurdity. I maintain that this evidence (although scarcely so conclusive as that which has preceded it) affords strong grounds for believing that the valleys of the Alps were never completely filled by glaciers and therefore that the valleys were not excavated by glaciers.

The evidence from the *mouths* of the valleys of the Alps is not less hostile to Dr. Tyndall's theory. For, observe, 1. The glaciers existed for a briefer period at the mouths of the valleys than at their upper portions. 2. The glaciers must have moved there, as a rule, at a slower rate than at the upper portions; because, as a rule, the gradients at the mouths were more moderate, and frequently (as in the case of the Valley of Aosta) there was a dead level. 3. The glaciers had usually received, before arriving at the mouths of the valleys, the whole of their most important affluents, and must have been rapidly diminishing in volume. The conclusion which is inevitable from these considerations is, that the glaciers must have exercised less erosion at the mouths of the valleys than at their upper portions; and this conclusion agrees very well with that arrived at by Dr. Tyndall himself, namely—"Lower still the elevations diminish and the slopes become more gentle; the cutting power gradually relaxes, and finally the eroding agent quits the

* The italics are not in the original.

† See *Matériaux pour l'étude des Glaciers*, vol. i. part iii. p. 11. The same idea is repeated in many other places in the same work.

mountains altogether, and the grand effects which it produced in the earlier portion of its course entirely disappear."* But does this conclusion agree with the fact that the valleys are usually wider—much wider—at their mouths than elsewhere, and that the beds of the valleys at their mouths are at a lower level than at the upper extremities? If the glaciers had flowed *up* the valleys, these facts might be explicable; but they are unintelligible if the valleys were excavated by glaciers which flowed *down* them.

The mouths, the beds, the walls, and the terminations of the valleys, and the slopes of the mountains which bound them, proclaim alike that the present modeling of the Alps has been only slightly modified by glaciers. It would, however, be unreasonable to conclude, because such is the case, that glaciers are incompetent to excavate valleys under *any* circumstances; and, before taking leave of Professor Tyndall, it is only due to him to examine his opinions upon the subject. He is, like Professor Ramsay, a great believer in soft places. He believes that glaciers not only erode soft rocks more rapidly than hard ones (which is a reasonable belief), but he considers that all the chief inequalities which are now seen in valleys that have been eroded by glaciers are due to the greater or less resistancy of the rocks to the action of *the ice*. "Were its bed uniform in the first instance, the glacier would, in my opinion, *produce* the inequalities."† Now, I could not differ greatly from Dr. Tyndall, if he were to say that glaciers must erode soft rocks more rapidly than hard ones, and that they might, in consequence, ultimately produce inequalities, if set to work upon a smooth surface containing both hard and soft places. But he goes far beyond this. It is necessary for him to explain how it comes to pass that such masses are left behind as that at Montalto, at the entrance of the Valley of Aosta, or those upon which the castles of Sion stand. The valleys of Aosta and of the Rhone, he says, have been excavated by glaciers, yet here are these obstinate crags standing in the very centres of the valleys. They must have been exposed to the full force of the glaciers; nay, the ice-streams were evidently split by them, and had to flow upon either side and over them. "Assuredly," says Dr. Tyndall, "a glacier *is* competent to remove such barriers, and they probably have been ground down in some cases thousands of feet. But being of a more resisting material than the adjacent rock, they were not ground down to the level of that rock."‡ Examination of such masses has led me to form a very different opinion. The contours of their rocks, upon the sides opposed to the direction of the flow of the glaciers, are frequently flatter, and suggestive of a greater degree of abrasion, than the adjacent and lower rocks.

* *Phil. Mag.*, Oct. 1864, p. 264.
† *Phil. Mag.*, Oct. 1864, p. 264.
‡ *Phil. Mag.*, Oct. 1864, p. 266.

They have been lowered *more*, not less, than their surroundings. Yet the indications, are, as a rule, that these obtrusive crags have only been lowered to a trifling extent, and, most certainly, not thousands of feet. Still, let us suppose, for the sake of argument, that the adjacent rocks were actually softer, and *were* ground down a hundred or more feet upon each side of the hard crags, which, in consequence, became that amount above the level of their surroundings. The adjacent rocks would then, according to my opinion, have been prodigiously eroded; all their angles would have been obliterated; they would have become exceeding flat, and such forms as they would present would be characteristic of a high degree of glaciation. Yet we find that such is *not* the case. The rocks adjacent to the crags are frequently *less* flat, *less* abraded than the crags,* and, to all appearance, their surfaces have not been lowered more than a very few feet. The conclusions are inevitable in such cases that the adjacent rocks have suffered *less* than the obtrusive crags, and that any real or imaginary softness of rock has not assisted glacier-erosion to the extent assumed by Dr. Tyndall.

The enormous amount of excavation assumed by Dr. Tyndall is further accounted for by him upon the supposition that glaciers are competent to "root masses (of rock) bodily away."† He seems to feel that mere grinding, rasping, and polishing would not be equal to the production of valleys, thousands of feet in depth, in any reasonable length of time, and so invokes this quicker process to get himself out of the difficulty. When and how Dr. Tyndall became possessed of this extraordinary idea I have no means of telling. Comparison of the following passages would lead one to suppose that it was acquired posterior to the publication of his *Glaciers of the Alps* :—

"The lighter débris is scattered by the winds far and wide over the glacier, sullying the purity of its surface. Loose shingle rattles at intervals down the sides of the mountains, and falls upon the ice where it touches the rocks. Large rocks are continually let loose, which come jumping from ledge to ledge, the cohesion of some being proof against the shocks which they experience; while others, when they hit the rocks, burst like bomb-shells, and shower their fragments upon the ice. Thus the glacier is incessantly loaded along its borders with the ruins of the mountains which limit it."—*Glaciers of the Alps*, Chapter on Moraines, p. 263 (1860).

"In the vast quantities of moraine-matter which cumbers many of the valleys we have also suggestions as to the magnitude of the erosion which has taken place. This moraine-matter, moreover, *is only in part* derived from the falling of rocks from the eminences upon the glacier; it is also *in great part derived from the grinding and ploughing-out of the glacier itself*. This accounts for the maguitude of many of these ancient moraines, which date from a period when almost all the mountains were covered with ice and snow, and when consequently the quantity of moraine-matter derived from the naked crests cannot have been considerable."—*Phil. Mag.*, Oct. 1864, p. 271.

* I do not know an instance where the reverse is the case.

† *Phil. Mag.*, Oct. 1864, p. 265.

It has been already shown (pp. 115–6) that the notion that the mountains were completely covered by glaciers (or anything like completely covered) is erroneous, and the evidence which leads to that conclusion is clearly supported by the fact that a great proportion (I think it may be said *the* great proportion) of the materials are *angular* which compose the moraines of the past, as well as of the existing glaciers of the Alps.* Their angularity is a certain proof that they were borne ***upon*** the glaciers, and were not transported ***under*** them. For, if they had been forced along underneath the ice, they would most certainly have become, at the least, subangular, or rounded or scratched. It is well known that this is what takes place at the present time in regard to débris underneath glaciers, and that the pebbles and boulders which are moved along in such a way acquire a character of their own which is unmistakable. The moraines, then, do not support, but clearly reject, Dr. Tyndall's notion. Nor is the evidence of the rocks from which he supposes that masses have been "rooted away" less distinctly against him. How could these masses be broken away without angular surfaces being left behind? and how is it that in those places where glacier-action has been *most* powerful angular surfaces are *most wanting?* Dr. Tyndall appeals to the *magnitude* of the old glaciers, and to the enormous *pressure* which they exerted upon their beds, to explain his "rooting away," as confidently as if his case was completely proved thereby. Yet, in those places where glaciers are and have been the greatest, and where their pressure has been the most tremendous, and exerted for the greatest length of time, we find the rocks which have been worked upon are the most highly polished, the most flat in contour, and the most devoid of all angularity whatsoever!

It is clear, therefore, that the theory of "soft places," as applied by Dr. Tyndall, cannot be sustained, and does not in the least assist us to determine how far glaciers are competent to excavate valleys. The idea is plausible that soft rocks must suffer under the grinding of glaciers more rapidly than hard ones, and may be admitted; but it will be shown presently that there are things to be said upon the other side. The notion that glaciers root away masses of rock incessantly, or to any great extent, must be unhesitatingly rejected as being opposed to reason and to facts.† However, "confining the action of glaciers to the simple rubbing away of the rocks, and allowing them sufficient time to act, it is not a matter of opinion, but a physical certainty, that they" would pro-

* I am, of course, aware that there are glacial deposits in Great Britain, and elsewhere, in which subangular and scratched stones are largely in excess of those which are simply angular. The manner in which such deposits were formed is not yet clearly understood.

† It has been already admitted that the minor asperities of rocks suffer, and may be actually crushed or scraped away. That this happens cannot be doubted, but this (comparatively) speedily comes to an end. It is mere brushing of the surface preparatory to polishing.

duce cavities or depressions of one sort or another. Given ***eternity***, glaciers might even grind out valleys of a peculiar kind. Such valleys would bear remarkably little resemblance to the valleys of the Alps. They might be interesting, but they would be miserably unpicturesque. The hob-nailed boots of the Alpine tourists would be useless in them; we should have to employ felt slippers or skates.

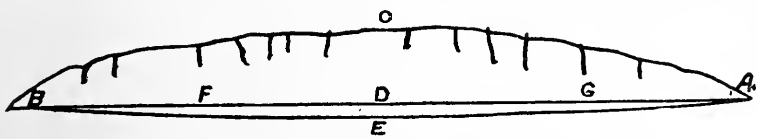
I have advanced only a few of the more obvious objections to Dr. Tyndall's theory. Many others might be urged, for the position taken up by the Doctor has been from the first an essentially false one, and has permitted him to be attacked from nearly every direction. Had he confined himself to stating that glaciers were competent to excavate valleys, without offering examples, and without attempting to show how they would do it, many persons might have differed from him, but would have done so chiefly ***in degree***. The declaration that the valleys of the Alps had been so excavated was a statement of a much more advanced and of a much graver nature, and I cannot but think that in making it Dr. Tyndall has materially retarded the progress of knowledge. There are many persons, I am convinced, who would learn with satisfaction that he repudiates a doctrine which can be disproved in a multitude of ways, and which is flatly contradicted by a host of facts.

Whatever may be the popular opinion about Professor Ramsay's theory regarding the formation of rock-basins, its author is entitled to credit for having attempted to grapple with an acknowledged difficulty, and to be congratulated upon the number of valuable facts which he has elicited. Exceptions can be taken to it, of course. It may be asked, at the very outset, Is it absolutely necessary to accept this dogma that the *only* remaining agent is the denuding power of ice? Have we arrived at the end of all knowledge? And the cogency of the reasoning may be doubted by which the conclusion is derived, that rock-basins have necessarily been excavated by ice, because they are commonly found in districts which were formerly covered by glacier. It may be said that the connection which has been shown between the two* may be nothing more than an accidental coincidence, and that, taken by itself, it is scarcely more convincing than that icebergs have made the Arctic seas, because those seas are full of icebergs. Such objections, however, do not touch Professor Ramsay's main arguments; and I think that any one who honestly endeavors to master them

* Professor Ramsay claims to be the first who has pointed out this connection. Professor Dana extends the statement still further:—"Another great fact that belongs to the Drift latitudes on all the continents, and may have the same origin, is the occurrence, on the coasts, of fiord valleys.—deep, narrow channels, occupied by the sea, and extending inward often 50 or 100 mile."*Manual of Geology*, 1867, p. 541.

will feel that they are very ingenious, and that they are by no means easy to refute.

It is impossible to deny a certain limited power of erosion to glaciers; and it is difficult to see why a great glacier should not make a hollow (a shallow one) if it were to come down upon a plain, and work there for a long time. For example, let A C B D, in the accompanying diagram, be a transverse section of a glacier which is moving over level ground, A G D F B. The glacier would naturally be thickest towards the centre, and its motion would probably be greatest in the same neighborhood. It should therefore erode its bed to a greater extent at or about the point D than anywhere else; and as the motion and weight of the ice would be greater at or about F and G than at points between F B or G A, so also would the erosion be greater thereabouts. In short, it is reasonable to conclude that in course of time the glacier might form a hollow in its previously level bed, such as is represented by the dotted line A E B. This would account for the hollowing out of rock-basins across their shorter axes. I do not merely think that



this is what *might* happen, but that it is what *must* happen in course of time; and saying as much is practically admitting the power of glaciers to produce concavities in large areas of rock. It may seem now as if all were conceded that is required by Professor Ramsay. It is not so. His principle appears to me to be sound, but his conclusions entirely unwarrantable. There is not the least doubt that rocks underneath the thicker parts of the existing glaciers are being eroded to a greater extent than those which are covered by a small amount of ice. The same must have happened during the glacial period. But these differences in the depth of the erosion may, I think, be disregarded, because the difference between the maximum and the minimum in any given area would not amount to more than a very few feet; as the evidence which has already been recounted tends to show that glacier-erosion has been insignificant at any and every part of the valleys; and the valleys, it must always be remembered, were occupied by the glaciers for more time than the plains out of which Professor Ramsay would have us believe that his great lake-basins were excavated.

To the foregoing remarks the Professor has two answers. First, he has the idea that the retardation which a glacier would experience upon its arrival on a plain would tend to "heap-up" the ice (see p. 112). This is no doubt correct. He considers that the glacier would in consequence "attain an unusual thickness, thus exercising, after its descent, an extra erosive power." Here we get into the region of surmises. To this we may demur. For he overlooks, or, at least, does not notice, that the glacier would be melting at a rapid rate, at or near its end, and that, in all probability, the extra ablation would counterbalance whatever thickening might arise from the tendency to "heap-up." The "unusual thickness" by which he gets his "extra erosive power," is entirely conjectural, and, judging by the glaciers of the present time, it is very doubtful if it had any existence whatever. If the Professor could point to a single glacier which is doubled in thickness through retardation, he would materially fortify his argument; but, in the absence of any such evidence, we may be permitted to doubt if there is much force in his idea.*

Secondly, the great basins which Professor Ramsay believes were excavated by glaciers,† are assumed to have been scooped out of areas filled by especially soft strata, which were removed with comparative facility, and at a rapid rate. Very eminent geologists disbelieve in the existence of these especially soft areas.‡ Others, again, offer evidence which leads us to believe that some of the great Alpine lake-basins existed *before* the glacial period.§ But let us suppose that they are all wrong, and that the Professor is right. Let us suppose, too, that retardation actually *doubled* the thickness of the glaciers. Taking all this for granted, it is still incomprehensible how the ancient glacier of the Rhone managed to excavate the bed of the Lake of Geneva to the depth of 984 feet (opposite to Evian), when it was unable to remove a tenth part of that amount from the Valley of the Rhone (say between Sion and Sierre); for it was working for a greater length of time in the valley, and no doubt with a *higher* rate of motion, than it was upon the bed of the Lake of Geneva.

I have often wondered, considering the extent to which Professors Ramsay and Tyndall lean upon soft places, that they, or some of their adherents, have not thought it worth while to point out examples, upon a small and upon a large scale, of soft rocks which have been eroded by glaciers to a greater extent than harder rocks in their immediate vicinity. If Professor Ramsay is correct in supposing that glaciers wear away soft rocks with *much* greater

*No one can consult the excellent map which accompanies Martins' and Gastaldi's *Terrains Superficiels* without seeing in a moment, from the disposition of the moraines, that the great glacier of Aosta *spread itself out directly it arrived upon the plain*. Hence, any material thickening through retardation was impossible. It can readily be shown that this *spreading-out* frequently occurs to the glaciers of the present time, when they pass from confined places on to open spaces (places where the valleys widen).

†The basins of the Lakes of Geneva, Neuchâtel, Thun, Zug, Lucerne, Zurich, Constance, etc. etc.

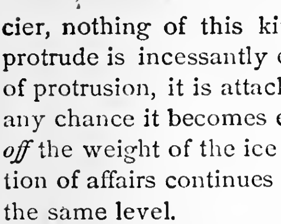
‡For example, see the remarks of Prof. Favre upon the Lake of Geneva, in *Phil. Mag.*, March 1865.

§Sir Charles Lyell, for example. In regard to the Lakes of Zurich. etc., see his *Antiquity of Man*, 3d ed., pp. 314–16.

rapidity than hard ones, it ought to be a very easy thing to produce examples. Yet, as far as I know, not one of the principal writers upon the subject has ever attempted to *prove* that glacier-erosion proceeds at an accelerated rate upon soft rocks, and is retarded by hard ones. It has been repeatedly asserted, or assumed, that such is the case, but proofs have been very rarely advanced.

Whilst this is the case, it has been continually remarked by writers upon glacier-action (who have not, however, attached any particular importance to the fact), that quartz-veins are cut down, by the passage of ice over them, to the level of the rocks in which they are found. Quartz, one of the very hardest of commonly diffused minerals, is unable to resist the grinding of glacier. Its hardness does not prevent its being polished down to the same extent as the much less resistant rocks which enclose it. If it suffered less than its surroundings, it would, of course, protrude. It does not, because it is eroded *equally* with the much softer rock. No distinction is made by the glacier, and the presence of the quartz is not sensible to the touch from any elevation or depression.

If glacier-eroded rocks containing veins of quartz are exposed to the influences of sun, frost, and water, it is not long before the quartz begins to assert its superior resistancy. If it is in gneiss, the gneiss in contact with it speedily suffers. Minute cracks radiate from the junction of the two substances over the surface of the weaker material. Water enters the tiny fissures, and, expanding under the influence of cold, rends away grain by grain, until at length, as in the accompanying diagram at A and B, little ravines are formed upon each side of the quartz-vein Q.*



If, on the other hand, the eroded rocks continue to experience the grinding of glacier, nothing of this kind results. The tendency of the quartz to protrude is incessantly checked, because, at the slightest suspicion of protrusion, it is attacked by the ice with increased power. If by any chance it becomes elevated above the surrounding rock, it *bears off* the weight of the ice from the surrounding rock, and this condition of affairs continues until both quartz and gneiss are brought to the same level.

There is little difference of opinion about these matters. It is perfectly well known that projections in the bed of a glacier are attacked by the ice, and that depressions escape abrasion through

*In Greenland I have seen gneiss cracked away from quartz-veins in glacier-eroded rocks, in this manner, to a depth of two inches and more. Where the same veins had been protected from the atmosphere, they were without the little trenches on each side. To the same effect see Geikie *On Modern Denudation*, Trans. Geol. Soc. Glasgow, 1868.

the protection afforded by the eminences.* Hence it is that ultimately all angles and almost all curves are obliterated from the surfaces of rocks upon which glaciers work. Hence it is that in a district which has been severely eroded by glacier we find the rocks more flat—that is, less convex—than in one which has been less eroded.

It is evident, then, that glacier does not and cannot dig away into soft places occupying *limited areas.* This is not a matter of opinion, but a certainty; and it seems to me to be entirely unwarrantable to assert, in the face of a well-ascertained fact like this, that the pools and small tarns lying in rock-basins (which are numerous in almost all mountainous countries) owe their existence to the excavating power of glacier, merely because glacier has passed over the spots which they occupy; and, to say the least, to be injudicious to apply terms like "scooping out" to the rounding and polishing-up of the beds of such pools, because those terms convey an impression that is entirely erroneous. The hollows in which such pools are found would necessarily have been obliterated, not deepened, if the glaciers had worked for a greater length of time.†

Professor Ramsay holds the directly contrary opinion. Unless I am entirely mistaken in regard to his ideas, he supposes that the beds of almost all pools, tarns, and lakes, which lie in true rock-basins, have been scooped out or excavated by glaciers. As a rule he does not consider that these lakes occupy hollows which were formed either entirely or in part through upheaval or subsidence, (either or both), or antecedent erosion, but that the lake-basins are simply holes which glaciers have dug out. How or in what way the glaciers did the work, I have not the most remote idea. I turn the Professor's pages over and over without gaining the slightest clue.‡ But I gather from the *Proceedings of the Geological Society*, that it was from the examination of the small pools he first came to the conclusion that glaciers scooped out basins in rock; that he was at first "too timid to include the larger lakes;" and that

* "In descending from the summit of the Weisshorn on the 19th of August last I found, near the flanks of one of its glaciers, *a portion of the ice completely roofing a hollow, over which it had been urged without being squeezed into it.*"—Tyndall's *Mountaineering* in 1861, p. 73. Dr. Tyndall's testimony is especially valuable, because he is by no means prejudiced in favor of the views which I am supporting.

† Sir Charles Lyell remarks with much force, in the 6th ed. of his *Elements*, p. 170, "Where opportunities are enjoyed of seeing part of a valley from which a glacier has retreated in historical times, no basin-shaped hollows are conspicuous. Dome-shaped protuberances, the *roches moutonnées*, before described, are frequent; but the converse of them, or cup-and-saucer-shaped cavities, are wanting." The justness of these observations is undeniable. The perusal of Professor Ramsay's papers would lead any one personally unacquainted with glacier-eroded rocks to conclude that the reverse was the case—that saucer-shaped hollows were abundant, or, in other words, that concavities predominated.

‡ I cannot find anything more explicit than this:—"The greater number lie in *rock-basins* formed by the grinding of glacier-ice." This is simple assertion; now for the proof. "Sometimes in the convolutions of the strata (conjoined with preglacial denudations subsequent to the contortion of the beds) softer parts of the country *may* have been scooped out; but *perhaps* more generally they were formed by the greater thickness and weight of glacier-ice on *particular areas*, due to *accidents* to which it is now often difficult or impossible to find the clue."—*Proc. Geol. Soc.*, 1862, p. 188.

becoming convinced the larger lakes occupied true rock-basins, he included them in the category of lakes which had been formed by the agency of glacier, because glacier alone, in his opinion, is capable of excavating true rock-basins!

The smaller idea has been shown to be fallacious, and it might be said that the larger one, which is built upon it, necessarily falls through. This is scarcely the case. The former deals with square yards, and the latter with square miles. A glacier we know, as a matter of fact, polishes down a quartz-vein in the same way as it does a bed of soft limestone. A plane which is adapted for planing wood may cut through a nail in a plank whilst taking off a shaving. But the plane is unable to take a shaving off a solid mass of iron, and it might be said, with some plausibility, that a glacier might be equally impotent if it had to work over square miles of quartz instead of square feet. To form a just idea of the probability of a glacier producing a lake-basin in one place (in soft strata), when during the same, or a longer, period, it only slightly erodes the surface at another place (hard strata), we ought to find out the effects which are actually produced by glaciers when working over a series of strata of unequal hardness, where the strike of the beds coincides with the direction of the motion of the ice. The idea, indeed, has often occurred to me, that insignificant quartz-veins might resist the grinding of glacier if they were worked upon longitudinally. It is not, of course, an easy thing to find a vein of quartz which has been worked upon longitudinally for a considerable distance; and I have never observed a better example than that which is described in the following paragraph.

In 1867, upon the shores of a fiord, about nine miles to the east of the settlement of Claushavn in North Greenland, I had the good fortune to discover the finest examples of *roches nivelées* which I have seen anywhere. The great interior *mer de glace* was near at hand, and a branch of it closed the inlet with an unbroken wall of ice, which was nearly a mile across. This branch had formerly filled the fiord, and had apparently covered the place to which I refer at no very remote date. Tremendous evidences of its power had been left behind. The gneiss upon the shores was literally levelled, and extended for hundreds of yards in continuous sheets, with polished surfaces destitute of all detritus, difficult to walk upon, for there was nothing to arrest the feet when they slipped. In these rocks there were two great veins of quartz, each three to four feet thick, which attracted notice at a considerable distance by their excessive brilliancy when the sun fell upon them. These ran roughly parallel to each other for about eighty yards, and throughout that distance their direction had nearly coincided with that in which the glacier had moved. The glacier had passed over them at an angle of about 10°. Upon this quartz my hammer danced and rang, and made scarcely any impression. I chipped away the gneiss without difficulty. The glacier had worked upon two substances of unequal resistancy. Yet, if a line had been stretched between the highest points across any hundred feet of these sheets of rock, I do not think that any part of the rock would have been depressed one foot below the cord. The quartz, instead of standing up in ridges, as I thought it might have done, was cut down to the same level as the gneiss; the keenest scrutiny could not detect the least difference.

It was evident, from the entire obliteration of form, that these rocks had had enormous power exerted upon them, and that a not inconsiderable depth of rock had been removed. It is immaterial whether the effects had been produced by comparatively limited force spread over an enormous length of time, or whether by greater force in a less time. The same effects would have been produced if the same amount of abrading power had been exerted over an equal area of similar rock in the Alps. But it is doubtful, perhaps, if there is in the Alps an equal area of rock which can be compared for perfection of glaciation to that of which I have spoken. I think it may certainly be asserted that there is not either in the Valley of the Rhone or in the Valley of Aosta. The glacier-eroded rocks of those valleys, and of the Alps generally, are notable for their convexity, and this affords evidence that the Alps have been subjected to less abrading power than the district in Greenland to the east of Claushavn. Now, if there is any truth in the assumption that glaciers dig away into soft rocks with much greater rapidity than into hard ones, there is, of course, greater opportunity for the exercise of this discriminative excavation when great power is exerted and when great erosion occurs, than when less power is exercised and less matter is removed. In Greenland, although enormous power has been exerted, and a considerable depth of rock has been undoubtedly removed, we find no appreciable distinction made in the treatment of two materials of very different degrees of hardness. How, then, is it possible to suppose that the prodigious amount of distinction could have been made which is assumed by Professor Ramsay in the less eroded Alps?

These are by no means the only obstacles which stand in the way of acceptance of his theory.* The difficulty is great of explaining how the glaciers excavated the rock-basins which exist, but it is still more troublesome to account for the non-existence of those which ought to have been made. The Professor explained at considerable length why they would not be formed upon steep ground

*For some of the more important objections, see Sir R. Murchison's Address to the Royal Geog. Soc. 1864; Sir C. Lyell's *Antiquity of Man* and *Elements of Geology*; Prof. Studer's *Origine des Lacs Suisses*; Prof. Favre in *Phil. Mag.* March 1865; and Mr. John Ball in *Phil. Mag.* Feb. 1863.

(§9, p. 316), and I cordially agree with the first part of his remarks; but he went on to say that when a glacier descended into a "flat valley the case was different. There, to use homely phrases, the ice had time to select soft places for excavation." "Why, then," asked several eminent persons—Mr. John Ball and Professor Favre amongst the number—"are there not lakes in the Valley of Aosta?" The valley is precisely the kind of one in which they should have been formed. Its inclination, as I have shown (p. 313), is very moderate, and several parts of it (the site of the city of Aosta, for example) are almost plains. The glacier which occupied it, one would have thought, was thick enough to have ground out basins in the rock at any part, and *retardation* thickened it still more, occasionally."* Are there no *soft places* throughout this great valley? Were there no *accidents*, which caused exceptional grinding on *particular areas*, throughout the whole of that long period during which the valley was occupied by glacier? Apparently there were not; anyhow, there are no lakes in the valley worthy of mention, nor are there, as far as can be told, any places where basins were excavated in the rock. The Professor evidently feels that the great glacier of Aosta did not behave as it should have done, and seems to be nettled by the references which have been made to its unaccountable remissness. "I have attempted," said he, "to explain why the rock-basins are present, and not why they are absent."† He had, in fact, already accounted for their non-formation. He had shown that the great valleys of the Alps were approximately the same in their general features before they were filled with ice as they are at the present time. He had brought forward proof that this was the case with the Valley of Aosta, had shown that the great glacier which issued on to the plain at Ivrea had been unable to remove loose river-gravel, and had declared explicitly that the reason was that *time* was wanting. The entire passage is as follows:—

"When lately south of the Alps, it was proved to me by Mr. Gastaldi,‡ that at the mouths of the great Alpine valleys opening on the plain of the Po, there were ancient alluvial fan-shaped masses of gravel quite analagous to those that by the agency of existing torrents have issued from the gorges on either side (for instance) of the valleys of the Rhone or the Dora, or of those that still issue at their mouths. These were deposited on a plain rather lower than the existing one, above Pliocene marine deposits, at a time when the true mountain valleys—at all events near their mouths—were just about as deep as they are now; for the great glaciers that filled the larger valleys issued out upon and over-flowed these low-lying river-gravels, and deposited their moraines *above* them, only in part scooping them away, apparently because the glaciers did not endure long enough of sufficient size to complete

* Professor Guyot has remarked striations ascending towards the mouth of the valley in places where the valley narrows. See Gastaldi's *Terrains Superficiels*.

† *Phil. Mag.*, Oct. 1864, pp. 305–6.

‡ Professor Gastaldi had published the same fact more than twelve years before. "On voit au ravin du torrent de Boriana, qui descend de la tourbière de San-Giovanni, que le terrain glaciare eparpillé supporte la moraine superficielle, et se confond lui-même avec le diluvium Alpin qui repose inférieurement sur le pliocène marin."—*Terrains Superficiels*, 1850.

their destruction. No better proof could be required that in great part the valleys of the Alps were approximately as deep before the glacial epoch as they are at present; and I believe, with the Italian geologists, that all that the glaciers as a whole effected was only slightly to deepen these valleys."—*Phil. Mag.*, Nov. 1862, p. 379.

This passage was, I presume, intended to upset the doctrines of Dr. Tyndall, and it did so, conclusively, as far as the mouth of the Valley of Aosta was concerned. It struck almost as severely at the opinions of its author. Indeed, there is scarcely anything more damaging to be found in the whole of the remarks which the publication of his original memoir called forth. At the mouth of the Valley of Aosta, during the glacial epoch, the whole of the conditions were found which Professor Ramsay requires for the formation of lake-basins. There was a *vast glacier* that issued out upon a plain, and which, in consequence of *retardation*, worked with unusual effect (?). It is demonstrable that it existed upon the plain for an *enormous length of time;* it is certain that it was *extraordinarily thick;* and the *particular area* upon which it worked was undoubtedly *favorable for excavation.* Yet the Professor is obliged to confess that the ice was unable to remove loose river-gravel lying upon the surface (indeed, that the glacier actually left another stratum of drift upon the gravel), and that the solid rock beneath did not experience any excavation whatever! There are many other places at which the same thing is known to have occurred, and so far from there being any especial tendency to excavate towards the snouts of glaciers, well-established facts lead rather to the opposite conclusion. A glacier which is bearing moraines always has those moraines brought together, jumbled together, towards its snout. Much of this moraine-matter falls down the sides of the glacier, and gets wedged between the ice and the bed-rock; much more falls over the terminal face of ice, and forms a stratum over which the glacier has to pass. This continually happens as the glacier progresses; and until this stratum, interposed by the glacier itself, is ground away, the bed-rock (or whatever may happen to be over the bed-rock) is not assailed. The evidence is that the stratum of glacial drift which was deposited in this way at the mouth of the Valley of Aosta was able to resist the grinding of the glacier during the whole of its prolonged operations around Ivrea, and this fact gives, perhaps, a clearer idea of the extremely limited power of glaciers for excavation than any other which can be brought forward.

The weight of evidence seems to me to bear heavily against Professor Ramsay's theory. In support of it, he has literally nothing more than the facts that glaciers abrade rocks over which they pass, and that there are numerous rock-basins (occupied or not occupied by lakes) lying within areas which were formerly covered by glacier. Here certainty ends. There are nothing but conjectures left, most of which have not even probability on their side. The idea that all petty pools and small tarns (which lie in rock-basins) occupy areas which have been subjected to special grinding, seems to me to be fully as absurd as the notion that each one lies in an area of special subsidence; and if all the geologists in the world were to swear that it was a solemn verity, I could not believe it, after what I have seen of the behavior of glaciers upon rocks. The notion that the great lake-basins occupy areas that were filled with especially soft strata, which were subjected to exceptional grinding, seems to me not to be warranted. It is doubtful if the soft strata had any existence; it is doubtful if there was exceptional grinding; and it is highly improbable that the glaciers would have worked upon those basins at a rate ten, fifty, or a hundred times faster than they did in other places, even if the basins were filled with soft strata. More evidence is wanted upon this head; but it will be surprising if fresh facts upset those which have been already observed. Looking at all this doubt and conjecture on one side, and the numerous facts upon the other which prove that very small glacier-erosion has occurred throughout the Alps generally, and the extremely limited capacity of glaciers for excavation under any circumstances, it seems less probable that Professor Ramsay's theory will work its way to popular acceptance, than that it will quietly take its place amongst the exploded dogmas which are left behind in the progress of scientific inquiry.

NOTE.

If I were asked whether the action of glacier upon rocks should be considered as chiefly destructive or conservative, I should answer, without hesitation, principally as conservative. It is destructive, certainly, to a limited extent; but, like a mason who dresses a column that is to be afterwards polished, the glacier removes a small portion of the stone upon which it works, in order that the rest may be more effectually preserved. By obliterating the inequalities of the rock, and, consequently, by reducing the area of the surfaces which are exposed to the atmosphere to a minimum, the glacier, when it retires, leaves the rock in the best possible condition to withstand the attacks of heat, cold, and water.

It has been pointed out, times without number (even by those who are in the habit of accusing glaciers of the most frightful destructiveness), that the polished surfaces which they leave behind them seem to be imperishable. All who know are agreed that centuries, nay, *thousands* of years, pass away, and still the *roches moutonnées* retain their form.

In regard to the action of the glacier, when it is in full life and activity, all are not so agreed. But when one finds evidence that glaciers which existed through vast periods of time did nothing more than *round* pre-existing weathered forms, *dress* rough and uneven surfaces, and did not even entirely destroy the destructive work of the older and greater powers: while those powers were at the same time *delving* into the rocks which the glaciers were not covering; were *not* reducing the area of exposed surfaces, but, on the contrary, were continually increasing them, and were hurling down vast masses, of which but a small portion fell on to the glaciers (but which small portion probably equalled or exceeded in bulk all that the glaciers were removing), the conclusion can hardly be avoided that glaciers, in their life as well as after their death, either considered by themselves or in comparison with other powers, should be regarded eminently conservative in their acts and in their intentions.

VII.

GLACIAL EROSION IN NORWAY AND IN HIGH LATITUDES.* BY PROFESSOR J. W. SPENCER, PH.D., F.G.S., OF THE UNIVERSITY OF GEORGIA, STATE GEOLOGIST.

DURING the summer of 1886, it was my good fortune to visit the three largest snowfields in Norway, namely, the Folgefond, at the head of Hardangerfjord in southern Norway, whose area is 108 square miles; the Jostedalsfond, two degrees to the north, beyond Sognefjord, whose area is 580 square miles, and the largest snowfield in Europe; and the Svartisen, extending from just inside the arctic circle for forty-four miles northward. All of these snowfields send down glaciers to within from 50 to 1,200 feet of the sea. These snowfields are not basins like those in the Alps, but are mantles covering the tops of plateaus from 3,000 to 5,000 feet or more above the tide, from which great cañons suddenly descend to the sea, and extend themselves as fjords, from 1,000 to 4,000 feet in depth.

Many of the Norwegian glaciers are rapidly advancing. In their progress they do not conform to the surfaces over which they pass, but are apt to arch over from rock to rock and point to point, especially as they are descending the ice-falls. Thus are produced great caverns into which the explorer can often wind his way for long distances.

Beneath the glaciers of Fondal, Tunsbergdal, and Buardal, in the northern, north-central, and south-central snowfields of Norway, as well as under other glaciers, I observed many stones enclosed in ice, resting upon the rocks, to whose surfaces—sometimes flat, sometimes sloping steeply—they adhered by friction, and by the pressure of the superincumbent weight. Although held in the ice on four sides, with a force pushing downward, the viscosity of the ice, or the resistance of its molecules in disengaging themselves from each other in order to flow, was less than that of the friction between the loose stones and the rock; consequently the ice flowed around and over the stones, leaving long grooves upon

*Read before the Royal Society of Canada, May 25, 1887, and the American Association for the Advancement of Science, New York, Aug. 1887. Proc. Roy. Soc. of Canada, 1888. American Naturalist, 1888. See also "The Erosive Power of Glaciers as seen in Norway," Geol. Mag., London, Dec., iii., vol. iv., 1887, and "Ice Action in High Latitudes," ibid., vol. v., 1888, by Prof J. W. Spencer, Ph.D., F.G.S.

the under-surfaces of the glacier. The first observation made was at Fondalsbræen (Fig. 1), where an angular stone (Fig. 1 *d*) whose section was ten by eighteen inches, rested upon the sloping face of smooth rock (*a*). For twenty feet below the stone, the under-surface of the glacier was grooved (*f*) by the moulding of the ice about the obstacle. This distance showed the advance of the glacier after the stone had come in contact with the rock, for it had evidently been completely buried at the lower end of the groove, before the ice had begun to flow about it. As the ice between the stone and the rock gradually disappears, the embedded stone does not suddenly cease to move, but drags, until enough of the surface rests upon the rock to allow of friction between the two granitoid surfaces to overcome the viscosity of the ice, when the latter flows around the obstacle. Elsewhere, an example was seen of this action. The knife edge of a wedge-shaped piece of gneiss was

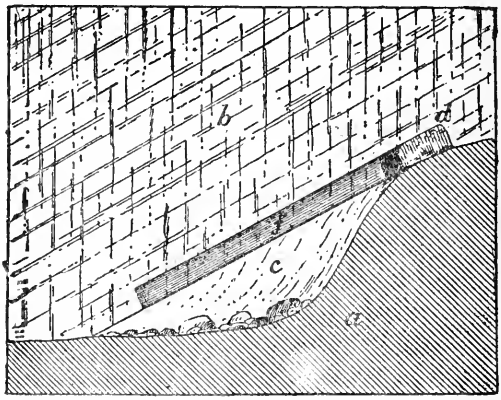


Fig. 1.—Section of Fondalsbræen, *a*, bed rock; *c*, cavern under glacier *b*; *d*, loose stone; *f*, groove under the ice.

protruding beneath the ice and resting upon the rock. The front end of this stone had moved beyond the subjacent surface, while the posterior end was still upon it. Yet the sharpness of the edge had scarcely been blunted.

Abundant examples were found to show that the flowing of the ice about loose obstacles was quite the rule. Both large and small (even an inch in length), angular and rounded masses, lying either upon the rock, or upon morainic matter, were sufficient to channel the bottom of an advancing glacier. No blocks of rock were seen in the act of being torn loose from the floor or sides of the valley, and certainly there were no loose or solid masses being picked up by the advancing glacier.

At Tunsbergdalsbræen (Fig. 2), whose lower end is 1,600 feet above the sea, a modification of the above described phenomena was seen. A roughly rounded boulder (Fig. 2 *d*) of thirty inches diameter was enclosed in the convex side of the glacier, which rose above it from thirty to forty feet in height. It was resting upon a surface, sloping at a high angle, and was held in place by the ice itself. As the surface of the stone, bearing upon the rock, was small compared with that held in the ice, it should have been dragged along. But it was being rolled, as shown by the moulding (*e e*) of its form in the glacier which was advancing faster than the stone was rolling down the steep slope. The pressure upon this

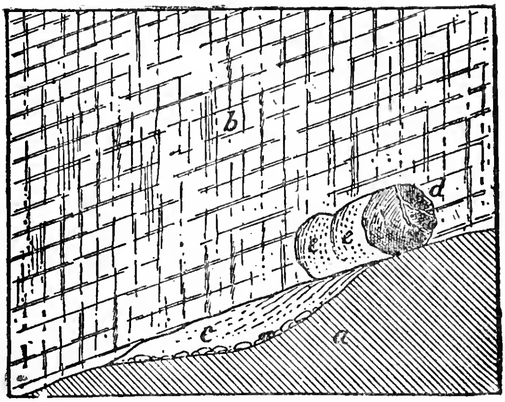


FIG. 2—Section of Tunsbergdalsbræen, *a*, bed rock; *c*, cavern under ice *b*; *d*, boulder; *ee*, moulding in ice of the form of *d*.

stone could not have been merely that of the superincumbent ice, a few feet thick, but also that of a powerful component of the weight of a glacier from 1,500 to 2,000 feet high descending more or less like a fluid. The energy upon the boulder was sufficient to crush it into one large and two smaller masses, together with stone dust. When seen, the three fragments had hardly begun to part company.

The abrasion of the solid rock by the fall of stones, and detached masses of ice and stones, was illustrated at the locality just named. The two guides and myself succeeded in detaching a large boulder of about five tons weight, adjacent to the edge of the glacier. It went rolling and sliding down a hundred feet or more, tearing away great blocks of ice which held a considerable amount of débris, and in its wake, the rock was more or less crushed or scratched.

A further example of the ability of the ice to flow like a plastic body was shown in a cavern (Fig. 3 *c*) 400 feet higher than the end of the glacier, where the temperature was 4°C., while that outside was 13°C. Upon the débris of the floor rested a rounded boulder (*d*) whose longer diameter measured thirty inches. A tongue of ice (*q*), in size more than a cubic yard, was hanging from the roof, and pressing against the stone. In place of pushing the stone along or flowing around it, the lower layer of ice above the tongue had yielded, and was bent backward as easily and gracefully as if it had been a thin sheet of lead, instead of one of ice a foot thick.

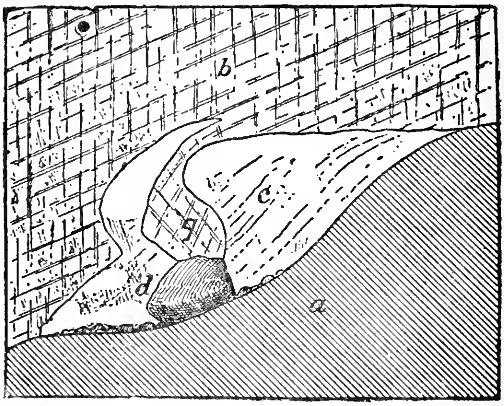


Fig. 3.--At Tunsbergdalsbræen, *d*, a loose boulder, resting on rock *a*, in cavern *c*, against which a tongue *q*, of the moving glacies, *b*, impiges and is bent backward.

According to the experiments of Herr Pfaff,* the temperature of ice has a great deal to do with its flow about obstacles. Below freezing-point, the movement is scarcely more than appreciable, while above that point, but not below, it may reach twenty-eight inches a day, or more. The conditions arising from the temperature beneath the glaciers are more or less favorable for the movement of the ice, as the lower surfaces are never entirely below freezing-point, even in winter. Professor S. A. Sexe† found that the water flowing from a Folgefond glacier, in February, 1861, had a temperature of 1°R., whilst that of the air was 7°R., below freezing-point.

The movement or flow of the ice about detached stones, resting upon rocks, has been observed by Professor Sexe beneath the Buarbræ, and by Professor J. W. Niles beneath the Aletsch glacier.‡ Professor Sexe illustrates the moulding of the ice about a loose stone, which was held beneath the glacier by a projection of the rock. My observations were upon stones, not held up by rocky projections, but upon surfaces often sloping downward. Although Professor Niles did not record observations showing that there was

* Nature, Aug. 19, 1875.

† Om Sneebræen Folgefon, af, S. A. Sexe.

‡ American Journal of Science, Nov., 1878.

definite movement of the stone, yet he concluded that there was a differential movement of the ice and the block. Whatever differential movement there is, it must be very inconsiderable, not only upon horizontal plains, but upon inclined surfaces. In the former case the movement of the ice is reduced almost to zero, as shown by the measurements of Professor Tyndall upon the Morteracht, where the velocity of the surface, some distance from its end, was fourteen inches, whilst that of the tongue of the glacier, as it reached the plain, was only two inches a day. *

The most important condition favorable for holding stones in ice as graving tools is low temperature, which impedes its progress; but this condition beneath glaciers does not generally exist. At higher temperatures, the velocity of the glacier is not great enough to overcome its plastic movement and to drag along detached blocks. However, when the whole mass of ice is charged with sand and stones, there is no doubt that polishing and scratching are effected; but when there are only occasional fragments in the bottom of the ice, as is commonly the case, the erosion from the sliding ceases as soon as the resistance due to friction between the stones and the rock equals that due to viscosity, which, as observations show, is soon reached. Consequently, we should not expect to find great troughs or grooves scooped out of solid rock by the actual glacier. These I have not seen about the existing glaciers of Norway, which are not dependent upon atmospheric and aqueous erosion and the texture of the rock, although their surfaces may have been subsequently polished. Generally speaking—as seen in the valley behind Fondalen Gaard, where the glacier is nearly free from sand, and contains comparatively few stones, as well as at many other places—the surfaces of the subjacent crystalline rocks, although of the form of *roches moutonnées*, with angles mostly removed are not smooth, but are as rough and as much weather-worn as similar rocks in warmer countries where no glaciers have been. Upon these surfaces, it is often difficult to discover scratches—even when present—for they are often so faint as to be only rendered apparent by moistening the rock. Even the face of the hummocks are commonly impertectly polished. In other places, particularly at Tunsbergdalbræen which contains much sand along the margin, the rocks are highly polished, and but little scratched. One is everywhere surprised to find beneath the glaciers the great paucity of glaciated stones, and in many terminal moraines they are scarcely, if at all, to be found.

The insufficiency of glaciers to act as great erosive agents is farther shown at Fondalen (Fig. 4), where a mass of ice thirty or forty feet thick abuts against a somewhat steep ridge of a rock,

* Tyndall's Forms of Water.

ten feet or less in height. In place of a stone-shod glacier sliding up and over the barrier, the lower part of the ice appears stationary, or else is moving around the barrier, while the upper strata bends and flows over the lower layers of ice (along the line *hh*, Fig. 4).

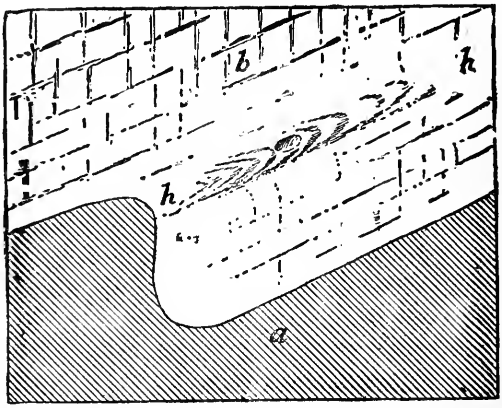


FIG. 4.—Section at Fondalsbræen, *hh*, zone along which ice (*b*) is flowing upon its lower layers.

When the barrier to the advance of a glacier is met with, whether composed of hard rock, or of morainic matter, the ice, provided it be sufficiently high, flows over upon itself, yet when the sheet is no higher than the barrier, the lateral thrust may push it up somewhat. The best example of the consequences of such a condition is to be seen at Svartisen glacier (Fig. 5), at the head of Holandsfjord, which descends to within sixty feet of the sea, where it ends in a morainic lake of considerable size, the northern

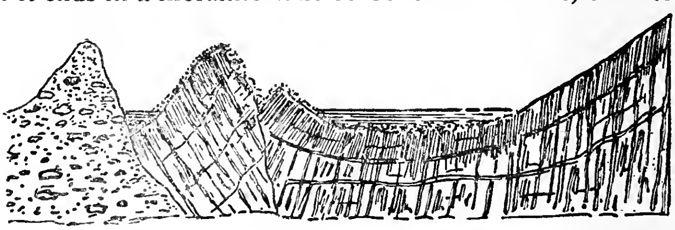


FIG. 5.—End of Svartisen glacier at head of Holandsfjord, moving through a lake against morainic barrier.

side of which is filled with the glacier. The water of the lake rises, in part, to the level of the ice, or over it, where the waves of the lake are depositing sand upon its surface. Part of the ice is not less than twenty-five feet thick, and most of it is probably double that thickness. Some of the strata of ice are pushed up and rest at 5° from the horizontal. But the interesting points are at the end of the glacier, where it impinges against the morainic barrier. Being unable to advance, the lateral pressure has forced up an anticlinal ridge or rather dome in the ice, to a height of fifteen feet, along whose axis there has been a fracture and fault. Upon this uplifted dome rests the undisturbed sand stratified in perfect conformity to the surface, which was formerly just below the level of the lake. As the ice about the line of fracture melts, the sand falls over and leaves a sand cone, of which there were examples—one at the end of the lake, and two in the centre—but the nuclei of the mounds were of solid ice. By this lifting process, pockets of loose clayey sand were thrown on top of the morainic matter, producing thus the appearance of having been ploughed up by the glacier to even several yards beyond its termination, which has not been the case.

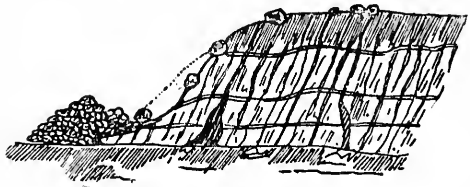


Fig. 6.—Buarbræen depositing morainic material upon a tongue of its ice, giving the false appearance of a glacial plough.

Nowhere is there apparently more ploughing action, and yet little or none to be seen, than at Buarbræ, which is advancing rapidly against a high lateral moraine. There is a large ridge (Fig. 6) of stone upon a thin snout of the glacier, just as if the ice were pushing under the boulders of earth. The glacier has a steep convex margin, from twenty to forty feet high, with many blocks and boulders upon it. These become detached, and, rolling down upon the lower tongues of ice, build up a ridge and leave a deep trough between it and the side of the glacier, and delay the melting of the layer of ice beneath, which is too thin to do any ploughing up of the moraine.

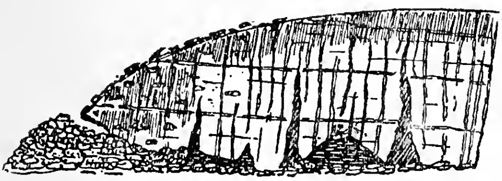


Fig. 7.—End of Suphellebræen advancing over a moraine.

An excellent illustion of a glacier advancing, without any ploughing action, over a moraine, and at the same time leveling it into a sort of ground moraine, was seen at Suphellebræen (Fig. 7). Here the glacier was moving up the slight elevation of a moraine produced by the early summer retreat of the glacier, although again advancing in July. The lower surfaces of the ice-tongue were furrowed by the loose stones of the soft incoherent water-soaked moraine, into which one's foot would sink when stepping upon it. The moraine was being levelled by the constant dripping of the water from the whole under-surface of the advancing glacier.

The glacier of Suphelle is the most remarkable of its kind, being a gigantic *glacier rêmanié*. From the Jostedalsfond, which, near the head of the valley of Fjærland fjord, is 3,000 to 4,000 feet high, the clear, bluish ice falls over a precipice of dark rocks for about 1,000 feet, and at about 1,500 or 2,000 feet above the sea begins to re-form into a glacier extending down into and nearly across the valley of Fjærland for a distance of somewhat less than a mile, to a level of only 175 feet above the sea. The glacier is much crevassed, and covered and filled with débris. In fact, it was the most dirt-laden glacier seen—not excepting the Aar glacier in the Alps. This material is wholly derived from the side of the mountain, and is brought down by frosts, and more largely by the fall of ice as it dashes from one frost-cracked rock to another. One of these great ice-avalanches I witnessed from the other side of the valley, fully a mile distant. Thousands of tons must have fallen at this time, but as the ice fell from rock to rock, it was converted into what, seen at the distance, appeared to be white dust. There are no considerable streams from the upper glacier, but from the rapidly melting glacier below the fall the volume of water laden with mud is large. As this glacier is not ploughing up, but leveling down the inequalities of its bed of loose material, we cannot suppose that the mud comes from any other than the dirt upon and within the ice, and that obtained by the dripping water as it levels the terminal moraine. This is only one of the examples everywhere to be seen showing the erroneous estimate of glacier-erosion, when based upon the amount of mud carried down by the streams flowing from the glacier; for the débris is brought upon their surfaces by other than grinding action, and, as far as observation goes, it is not derived from beneath them, at least, to any great extent.

Although I have seen some of the sharp angles of the rocks at 2,000 feet above the fjords along the sides of the valleys, somewhat rounded and scratched, yet the inqualities of the faces have not been removed by erosion of any kind. At numerous places in Norway, as well as in other countries, hummocks of rock rise above or out of the glaciers, as the ice flows around them at lower levels, these channels having been deepened, not by glaciers, but by subglacial streams.

Nowhere are the *roches moutonnées* so abundant as on the coast of Norway. In their more perfect form, they are not extensively developed along the coast at more than 250 feet above the sea. At higher altitudes they are best seen about glacier-falls, farther up the valleys. But during the Pleistocene days, the coast has been raised several hundred feet, at least. The form of the hummocks is precisely like what may be seen in southeastern Missouri and other States south of the line of northern drift, or are described as occurring in Ceylon, Brazil and other tropical countries, to which only are added the scratches. The forms of these hummocks must be principally attributed to the atmospheric erosion of the crystalline rocks where the débris has been swept away by currents or by ice. We see them more frequently swept clean upon the coasts of either cold or warm countries than in the interior, where the currents are only those from rain or local glaciers, for even the sweeping beneath the glaciers is principally effected by dripping waters or streams. Professor Kjerulf, of the University of Christiania, than whom there is no better authority, regards the production of hummocks and their glaciation up to a height of 600 feet upon the coast of Norway, as the result of floating ice.*

The absence of transported boulders and striations upon the surface of many parts of the high plateaus of Norway is doubtless, in part, attributable to the ability of ice to flow around loose obstacles, and the frequent want of higher ridges to furnish material by their débris falling upon the ice to work through the mass afterwards.

The faith in glaciers, as great erosive agents, has been so severely shaken that few geologists, who personally study those still existing, now attribute to them greater power than that of removing soft materials, and of this power many others are sceptical, *e.g.*, Professor Penck,† of the University of Vienna, who has been misquoted as having proved their great efficiency in eroding basins in hard rocks. To this scepticism, it seems to me that these notes must contribute; especially when glacial erosion is applied to the hypothetical excavation or modification of great lake-basins, and the transportation of the northern materials in the boulder clay over the broad plains of America, as there were no mountains of adequate height with peaks, or *séracs*, to supply the detritus sufficient to furnish the tops of the glaciers with all the boreal material of the drift, which "covers half a continent."

In connection with this paper, the observations of Herr Payer and other arctic explorers are important. The snow-line of Franz Joseph Land descends to within a thousand feet of the sea, and the numerous glaciers discharge great quantities of icebergs as they move down into the ocean. Payer says: "However diligently I look for them, I never saw unmistakable traces of grinding and polishing of rocks by glacier-action."‡

* Discourse before Meeting of Scandinavian Naturalists, Copenhagen, 1873.

† Geological Magazine, April, 1883.

‡ New Lands within the Arctic Circle, 1872-74.

Lieutenant Lockwood* found in central Grinnell Land a thick ice-cap, extending for a distance of from seventy to ninety miles, faced by an ice-wall of from 125 to 200 feet high, irrespective of topographical inequalities. It was free from rock débris, except in a valley confined by mountain-walls thousands of feet high. Along its foot there was almost an absence of morainic deposits, and even where present these were unimportant ridges. The general absence of rock and dirt in the arctic glaciers is a common subject or remark. The snow line in the high latitude of central Grinnell Land is 3,800 feet above the sea, and the glaciation of the rock about the adjacent Lake Hazen (500 feet above tide) is not recent.

In Spitzbergen, where the snow-line is much higher, striated rocks, according to Nordenksjold, occur only below 1,000 feet.† The same holds true for Labrador, where the scratches are confined to the lower thousand feet, although the mountains rise to 6,000 (Bell).‡

In the Antarctic regions, the officers of the "Challenger" remarked the absence of detritus in the icebergs and southern ice, although Wilkes and Ross saw rocks upon a few bergs. These last are supposed to have come from valleys in the volcanic mountains.

Indeed, outside of valleys, explorers in high latitudes have not found, in the margins of such ice-caps visited, the tools capable of great erosion. The continental area of North America presents very much lower and less abrupt prominences than the reliefs of Greenland, Grinnell Land, Spitzbergen or Franz Joseph Land. Overhanging mountains seem to be necessary to supply glaciers with tools by which alone any abrasions can be accomplished, and these conditions belong only to valleys of great mountain ranges. However, there is one condition under which glaciers, when shod with graving tools, ought to be great eroders, viz., when their motion is much more rapid than the flow of land ice,—which is almost invariably less than three feet a day, under which condition, included stones commonly adhere by friction to the subjacent rocks, and cause the lower surfaces of the ice to be grooved. This condition of extraordinarily rapid movement has been seen at Jacobshavn glacier in Greenland, where Professor Helland§ found a velocity of from forty to sixty feet a day. In Alaska, Lieutenant Schwatka‖ and Professor G. F. Wright¶ observed glacier movements of from forty to seventy feet a day. In these cases the

*Three Years of Arctic Service, 1881-4, Greely.

†See Geological Magazine, 1876.

‡Dr. Robert Bell, in Hudson's Bay Expedition of 1884.

§Ice-fjords of North Greenland, Quart. Jour. Geo. Soc., 1877, A. Helland.

‖"Times" Alaska Expedition, New York, 1886, Schwatka.

¶The Muir Glacier, Am. Jour. of Sci., 1887.

glaciers are moving into the sea, and the new element of partial flotation or sliding, which does not belong to land glaciers, is here introduced. The great velocity of these glaciers is far beyond any observed ability of ice to flow as plastic bodies; consequently, one is led to conclude that, under partial flotation, stones may be held firmly as graving tools by glaciers.

Hereby we are able to explain the occurrence, in many Alpine valleys, of a greater glaciation than we see in progress to-day, as being due to glaciers rapidly advancing into fjords, during a period of partial submergence.

The appeal to the greater magnitude of the glaciers, as producing effects not now seen as the result of those of the present day, seems to be begging the question, for the action of thicker glaciers differs from that of thinner in amount rather than in kind; for increased pressure, raising the temperature, increases the plasticity of the ice, as it is seldom if ever lower than freezing point. Consequently it seem improbable that stones should be held more firmly in glaciers of thousands of feet in thickness than in those of hundreds of feet. In addition, the friction between the stones held in the ice, and the surface of the subjacent rock, is proportionally increased by the greater weight of the glacier.

Over the vast area of action, the work of floating or sea-ice, in some forms, is enormous. On the northern side of Hudson Strait Dr. John Rae,* who had very extensive arctic experiences, found that snow drifting over precipices into the sea resulted in the formation of bergs, sometimes a hundred feet thick, filled with the loose rock débris of the coast, and having the form of the shore where formed. Most of them break loose and drift away to melt or become stranded elsewhere.

Greely describes the great momentum with which the floe-bergs come together. By their meeting the ice is crushed, and raised up into ridges fifty or sixty feet high.

One cannot read carefully the results of the British Arctic Expedition of 1875-6 without being impressed with the erosive power of drifting ice, moving with a velocity never acquired by glaciers. Floe-bergs are pushed upon a shelving sea-bottom, until the ice has risen from twenty to sixty feet, after their first stranding in perhaps only from eight to twelve fathoms of water, although weighing tens of thousands of tons.†

As the grounded floe-bergs are forced up the shelving sea-bottoms, ridges of earth and stones are pushed up in front of them. Floe-bergs which have been toppled over, thus showing their original bottoms, and also masses of pushed-up coast ice are found

* In Canadian Journal, Toronto, 1859.

† British Arctic Expedition of 1875-76, Sir George Nares.

to be grooved and to contain angular stones with their exposed surfaces scratched and polished. As the movement is greater than the velocity of glaciers flowing about obstacles, it is only natural to expect that the enclosed stones should be held firmly as graving tools, or be wrenched out owing to the brittleness of the ice under such great stress.

In describing the ice action on the coast of Labrador, Professor H. Y. Hind says the "pan-ice" (from five to twelve feet thick) is polishing the surfaces and sides of the rocky coast, and producing boulder clay. He says: "When the pans are pressed on the coast by winds, they accommodate themselves to all the sinuosities of the shore line, and being pushed by the unfailing arctic current, which brings down a constant supply of floe ice, the pans rise over all the low lying parts of the Islands, grinding and polishing exposed shores, and rasping those that are steep-to. The pans are shoved over the flat surfaces of the Islands, and remove with irresistible force every obstacle which opposes their thrust, for the attacks are constantly renewed by the ceaseless ice stream from the northwest, and this goes on uninterruptedly for a month or more."* Similar results elsewhere have been frequently recorded, as those of Professor Milne in Newfoundland.†

While the power of glaciers, under favorable conditions, to abrade and scratch rock surfaces, as "sand-paper" scratches "a cabinet," is not questioned; yet these observations, in Norway and elsewhere in high latitudes, all confirm the correctness of the verdict given by many geologists—especially in Europe—who have had the opportunity of personally studying living glaciers, that the potency of land-glaciers to act as great eroding agents, capable of "planing down half a continent," or ploughing out great valleys, or lake-basins, or even of greatly modifying them, is not only not proved, but most strongly negatived. Even the power of glaciers to abrade is reduced in many cases almost to zero.

*Notes on Some Geological Features of the Northeastern Coast of Labrador, Can. Nat. 1878.
†Ice and Ice Action, Newfoundland, Geol. Mag., 1876.

Beacon Lights of Science

MORAL TEACHINGS OF SCIENCE

BY

ARABELLA B. BUCKLEY

AUTHOR OF THE FAIRYLAND OF SCIENCE, THROUGH MAGIC GLASSES, LIFE AND HER CHILDREN, WINNERS IN LIFE'S RACE, A SHORT HISTORY OF NATURAL SCIENCE, ETC.

Everything in nature acts according to laws; the distinction of a rational being is the faculty of acting according to *consciousness* of laws.
KANT.

Thus the reproach is removed of laying the foundation of the noblest part of our nature in the base principle of selfishness. . .
DARWIN, *Descent of Man*.

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Beacon Lights of Science

MORAL TEACHINGS OF SCIENCE

CHAPTER I

"Can the stars' motions give me peace,
Or the herbs' virtues mine increase?"

COVENTRY PATMORE.

"Our understanding cannot in this body found itself but in sensible things, nor arrive so clearly to the knowledge of God and things invisible as by the orderly conning over the visible and inferior creation."—MILTON.

LET me beg of the reader not to pass lightly over the two quotations at the head of this article, for he will find in the second a noble and earnest answer to the first, though written two hundred years before it; and upon this answer will be grounded the arguments of our Science Teachings, in which we propose to consider how far science, or the study of the world outside ourselves, can help and guide us in the conduct of our life. That we want help, no one can doubt who looks around upon the turmoil of opinions in our day, the breaking down of old barriers, the rebellion against authority, and the confusion of men's notions of right and wrong. The very fundamental principles of religion and morality are often called in question—whether there be a God, and if there be one, whether He is omnipotent and benevolent; whether this life is all, or a preparation for a better one; whether it is best to be just and merciful, self-sacrificing and loving, or whether self-interest and selfish enjoyment are the end and aim of existence.

Nor are these questions mooted only by men who wish to make them an excuse for self-indulgence and vice. We live in an age of earnest scepticism, when thoughtful people of every class are filled with a passionate desire for truth at all costs; they imperatively demand a reason for the doctrines that are presented to them, and will act only upon sincere personal convictions, however crude these may be. The very leaders of knowledge are sharply divided in opinion. Theology is now studied as a science, and points are disputed which in the age of our forefathers were accepted without discussion; while the rapid spread of scientific discovery has discredited many dogmas of earlier days, under which, nevertheless, deep truths are hidden. Those who are gradually tracing out, step by step, unvarying law and order in the universe, cannot accept much which was readily believed before the immutability of natural law was either known or suspected; while those who have not made natural laws their special study, are pained and shocked at being called upon to reconsider deeply-rooted and cherished beliefs.

Now all this would not in itself be hurtful, if belief were not needed for everyday conduct. So long as both sides are seeking truth, they are certain in the end to rise above the clouds of confusion into the higher regions where all broken lights merge into one. But life consists in action, and for right action men need steady principles. All people are not earnest, and even many who are, cannot think out their own standpoint, but accept the prevailing thought of the day; and to these people a conflict of opinions concerning the higher questions of religion and morality becomes actually harmful. Perplexed, and weary of the constant discussions upon the most fundamental truths, they throw aside all belief in disgust; the better minds sink into perplexity and doubt, the meaner ones follow their selfish instincts without restraint. A correspondent from one of our colonies wrote the following sentence a short time ago in connection with a sad crime which had been committed: "The great danger in our day is that young men have no fixed principles to guide them; religion has lost its hold, and with it have gone the religious sanctions of morality. Right and wrong are becoming with them mere matters of expediency, a calculation as to what will best serve their ends."

Surely this is a very serious state of things, and one which cannot be cured by an appeal to doctrinal teaching, for the very root of the difficulty lies in the fact that the religions of the present day have ceased to influence many minds. In this dilemma it may be well to remember that there are two ways of approaching every question, from within outward, or from without inward. The first of these, the study of man's inner nature, has been from the earliest times the groundwork of religion and philosophy. The second, the study of the outside world, and of man's physical nature, has been the acknowledged domain of science. Yet these are not really two, but only different methods of arriving at one result, namely, the knowledge of the laws by which we and all the rest of nature are governed. If then the first seems to fail us, why should we not inquire whether the second will not afford us a firmer standpoint?

No doubt the higher questions of theology must always remain matters of inference and faith rather than of direct proof, though even these may be made more clear by "orderly conning over the visible and inferior creation." But our relations toward our fellowmen belong to this world and to our present daily life, and are intimately bound up with the whole history of living beings upon the earth. On this point, at least, science has a right to speak, and if we only desire to arrive at the truth we shall inquire fearlessly.

What we want is a sure and intelligible basis on which we can take our stand in the work of life. If selfishness is the universal law of progress, then the sooner we learn the truth the better. But if this is not so, we need have no fear that the study of natural laws will mislead us into believing it. With our limited knowledge we may often be perplexed, but so long as we do not overstrain the facts we shall not be confounded. If it be true that the instincts which lead us to be just and merciful, honest and unselfish, pure and affectionate, to fear moral degradation and to aspire to nobleness of character, are inherent in the very laws of our being, then we shall find the gradual development of these qualities in the ground-work of living nature. In a word, we shall find evidence that high moral duties are not true merely because all religions have taught them, but that all religions have taught them because they are true.

If we can establish this conclusion, though much must remain uncertain so long as our view is so limited, yet we shall have found firm ground upon which the scientific and religious sanctions of morality meet, affording a bulwark against the flood of scepticism as to all things noble and good, which threatens to overwhelm us.

Let us begin then by considering the most general and comprehensive conclusion which the study of science has been establishing for us during the last four hundred years. This conclusion, which even now is often disregarded by many practical and sensible people, is that the laws governing the universe are constant and unvarying so far as we can trace them. In the childhood of the world, when every event from the rising of the sun to the eclipse or an earthquake was a miracle unconnected with other events, it was impossible for men to learn anything of the true workings of nature; and even long after nations became civilized and very advanced in culture, science lagged behind. The field of accurate knowledge could only be conquered inch by inch by patient observers, and many scattered conclusions had to be formed and registered before they could be united into one system.

Even as late as the beginning of the seventeenth century men still believed that our little world was the centre of all things, and the sun, moon, and stars created simply for our use to give light by day and night; and those who care to examine carefully many beliefs of the present day will be surprised to find how much they are influenced by the survival of this ancient error, as for example when men speak of the whole scheme of creation, and of the intentions of the Diety as relating solely to our world and its inhabitants. Science, however, was slowly but surely dispelling this illusion. Ptolemy in the time of the Greeks had accurately worked out the movements of the sun and planets on the theory that they moved round our earth. Copernicus in the middle of the sixteenth century was able (precisely because Ptolemy had worked conscientiously and stated the facts accurately, so far as he knew them) to show that he was mistaken, and that our earth, together with the planets, moves round the sun. Then followed the discoveries of Galileo, the observations of Tycho Brahe, and the labors of Kepler, reducing the movements of the planets to definite laws; and finally, towards the end of the seventeenth century, Newton, by the discovery of gravitation, explained why the planets follow these laws, and established a theory of mutual attraction which holds true throughout the whole of the heavenly bodies of which we have any knowledge.

This discovery, which seems at first sight to have little or nothing to do with our inner nature, really gives us the standpoint upon which the lever of moral action must be placed to move mankind; for it was the thin end of the wedge which has slowly but surely driven out the idea of caprice, chance, and special interference from the universe.

The law of gravitation once established gave a strong impetus to astronomy. Laplace proved that it accounted for all the intricate movements of the solar system; and the mathematical calculations by which Adams and Leverrier discovered the unknown planet Neptune were founded entirely on the fact that the motion of Uranus was inconsistent with the law, unless caused by the attractions of some unseen body. So firm had become the conviction that this law is constant and unvarying in its action!

Meanwhile the stars, too, began to yield up their secrets. Halley and others showed that some stars had shifted their places since the days of Ptolemy, and that they are separated from us by such enormous distances that they must be mighty globes of light. It remained for Sir W. Herschel to prove that many of them are much larger and more brilliant than our sun, which, instead of being the centre of the universe, is one of the smaller stars, and is carrying our solar system toward a spot in the constellation Hercules at the rate of about half a million of miles a day.

Here, again, we have to give up our pre-eminence. Not only is our earth not the centre of the universe, but even our sun is but a small wandering star among the myriads of heavenly bodies, and we can no longer therefore reason as though the whole scheme of creation had been shaped with a view to the existence of man only, nor as if the concerns and destiny of our world were the end and aim of all things. What we lose on the one hand, however, we gain on the other, for our mind travels out into the universe, and together with our own littleness we learn the greatness and the constancy of the hidden Power which holds us in its grasp.

Yet one more conclusion remains to be noted. It was again the elder Herschel who discovered that the binary stars, such as Castor in the constellation Gemini, are two separate suns revolving round each other; and the mathematicians taking up the problem proved that such stars perform their revolutions in a definite time round a common centre exactly in accordance with the law of gravitation. "Thus," writes Sir Robert Ball,[1] "a whisper from the binary stars came across the vast abyss of space. That whisper told us that the law of gravitation is not peculiar to the solar

[1] *The Story of the Heavens*, p. 402.

system. It told us the law extended to the distant shores of the abyss in which our island is situated. It gives us grounds for believing that the law of gravitation is obeyed throughout the length, the breadth, the depth, and the height of the entire visible heavens."

So much then for the lessons of astronomy, and when we turn to other physical sciences the same truths meet us. In physics, as in astronomy, all discoveries and applications of the various forces rest upon the conviction, based upon experiment, that their action is constant and unvarying, and that apparent exceptions are due entirely to our ignorance.

Science has been gradually bringing all isolated facts under the reign of law, until at last all the physical forces, heat, light, electricity and magnetism, chemical affinity and cohesion have been proved to be but different forms of energy, or the power of doing work, so that when this energy disappears as light or heat, it reappears as electricity or chemical affinity, or does work in building up the cells of plants or of the tissues of animals. In like manner as we now know that the planets and stars revolve in regular and law-abiding order in the heavens, so we have proved by observation and experiment that the energy producing all physical activity is fixed and unvarying, disappearing in one form only to reappear in another.

When next we turn to the material of which our earth and other bodies are composed, the same conclusion reappears. For spectrum analysis has now shown that iron, sodium, calcium, hydrogen, and many other elements are common to our world, to the sun, and to the most distant stars and nebulæ ; obeying there the same conditions and laws as obtain on our globe. Nay, more! the most recent experiments made upon the so-called elements, in our laboratories, tend to lead us to the conclusion that they may be but different forms of one original substance, as heat and electricity are but different forms of energy.

So we are led on all sides to unity and uniformity of action, the apparent irregularities of nature due to our ignorance finding their place one after another as regular modes of manifestation of a great underlying cause too vast for us to grasp in its reality and entirety. And to this we must add one more inference which is becoming more clear and certain as science moves on—this is that the visible universe which we can examine has not been always as it is in our time, but is the result of gradual evolution and development. Even now spectrum analysis shows nebulæ in which matter is still in a state of gas, others in which stars are apparently forming, while in our own solar system everything points to the probable explanation that our earth and the other planets were once part of the sun and have been left behind during the condensation of the solar nebulæ, revolving around the central orb and gradually cooling down to their present condition. In our world we can carry the history still farther, for we have now traced the gradual development of living beings, the succession of higher and higher forms in the strata of the different geological periods, and the final crowning point in the appearance of man in later ages.

We see then that experience has invariably shown, as our knowledge has increased, that anything apparently capricious, anomalous, and irregular in the working of the visible universe arises only from our infirmity of vision. The farther we penetrate, the more orderly and regular is the sequence we discover, leading us to a settled conviction that the Will working behind and in the universe is unwavering and constant. "Thus," in the words of Mr. Herbert Spencer, "the consciousness of an Inscrutable Power, manifested to us through all phenomena, has been growing ever clearer, and must eventually be freed from its imperfections. The certainty that on the one hand such a power exists, while on the other hand its nature transcends intuition and is beyond imagination, is the certainty towards which intelligence has from the first been progressing. To this conclusion Science inevitably arrives as it reaches its confines; while to this conclusion Religion is irresistibly driven by criticism. And satisfying as it does the demands of the most rigorous logic at the same time that it gives the religious sentiment the widest possible sphere of action, it is the conclusion we are bound to accept without reserve or qualification." [1]

While, however, we must all freely admit that the *ultimate* nature and attributes of the great First Cause which we call "God" must transcend our utmost efforts of intuition or imagination, we cannot surely fail to recognize that partial manifestations of that nature are taking place within and around us at every moment of our lives. To allege, as some able men have done, that it is idle for us to attempt to discern the purposes and will of such a Cause in ourselves, or in the natural world around us, has always appeared to me to create a difficulty where none exists.

No one for a moment supposes that we shall ever form an exact conception of the universe, since every increase in our powers of observation and analysis shows that more and more lies beyond, and that it is impossible to reach the end. Yet this does not prevent us from understanding in a large measure the laws governing the portion we do see, as astronomy, of all the sciences, especially proves to us. In like manner our own existence and that of others is an absolute mystery, and the only available starting-point is our own consciousness, the nature of which is as inscrutable as that of the Deity. Yet we act daily upon our knowledge of the laws of human nature predicting results and finding our judgment correct.

By the same reasoning we can never hope to form an adequate conception of an Infinite First Cause. But those who for this reason would deny us a knowledge of God, seem to forget that the very forces acting in nature, and in ourselves, emanate from God *and would be non-existent without Him.* Whether, therefore, we consider the unvarying law and order

[1] *First Principles.*

of the physical universe, or the intelligence exhibited in the organic world and culminating in the self-consciousness and will of man, we are actually studying those phases in the nature of the First Cause of which these are the expression. On no hypothesis founded upon the facts of nature can we shut out His ever-present action, nor shake the self-evident truth that in Him all existence " lives and moves and has its being ; " while every step we take leads us more and more to the conviction that He is "without variableness or shadow of turning."

If then we can understand the working of the laws of the universe even in their lowest and simplest stage, we have just so far entered into the Will of which they form part. If we can guide our conduct by them, we must be moving in the line of least resistance and tending toward perfection. If by means of them we can arrive at a better understanding of our own infinitely more complex nature, we shall in so far arrive nearer to a comprehension of His infinite and often inscrutable attributes among which must be those from which originated the laws of our being.

Therefore when the poet asks, "Can the stars' motions give me peace?" we must surely answer "Yes." For in these, the most mechanical and therefore the least complex of nature's problems, we invariably find that constancy and stability, which are the foundation of all confidence. As a child in moments of terror looks into its parent's face, and seeing there calm and courage, trusts confidently that all is well, so man in moments of depression and helplessness must surely find rest in the starry heavens, an earnest to him of the great truth that caprice and uncertainty have no place in the universe, but that *his* life too is part of a fixed and stable purpose, emanating from Infinite Knowledge and Power.

CHAPTER II.

"All nature is but art unknown to thee;
All chance, direction which thou canst not see;
All discord, harmony not understood;
All partial evil, universal good;
And spite of pride, in erring reason's spite,
One truth is clear, whatever is, is right."—Pope.

FOR a long time after the unvarying action of law had been recognized in the inorganic world, no such generalization was applied to living beings. Each species of plant and animal was supposed to have been created at the beginning of the world, with a definite structure and habits of its own; and the similarity between the different forms was accounted for by their being all designed upon one general plan by the Creator.

The whole scheme of the living creation, with man at its head, seemed to lie altogether beyond the reach of investigation—God had made the endless diversity of living forms, but *how* He had made them was a mystery no one ever attempted to explain. Nor did the fact of the pain and distress suffered by all animals in the struggle for life and food seem to have caused any surprise. No thoughtful mind could deny that "the whole creation groaneth and travaileth in pain together until now;" but this was believed to be the result of man's fall, and the injustice of such an explanation did not suggest itself.

The first awakening to the extent of our ignorance on these points came from geology, and was a parallel in the world of life to the discovery in astronomy that our world is not the centre of the universe. In the early part of this century man first learnt that there has been a succession of living forms upon the globe. When Cuvier put together the bones of fossil animals found under Paris, and showed that they belonged to extinct species, different from any now living, he laid the foundation of the study of paleontology, which has since taught us that there was once a time when huge fish and amphibia were the chief animals in the world, another when reptiles had begun to flourish, while birds branched off and filled the air with feathered life; and again, that it was only in comparatively late geological ages that the mammalia became the most powerful creatures on the earth, ending in the advent of man himself.

This discovery of the successive appearance of the different classes of animals worked a change in our ideas concerning the living creation. In the first place, it forced men to consider what they meant by an animal being "created." It was one thing to talk vaguely about what happened at the beginning of the world, and another to try and imagine how an elephant, for example, appeared abruptly in the midst of other living beings and gave rise to a new species. Men of science began to cast about for some explanation of how these numerous forms had been produced one after the other; and the great French naturalist Lamarck suggested that the different species of animals were not separated creations, but had been gradually developed from a few simple living forms, so that in the course of long ages there had sprung up a great variety of animals in the world. This suggestion did not however gain much ground with naturalists, partly because the old opinions of the fixity of species were very strong, and partly because the cause of development on which Lamarck laid most stress—namely, the innate desire and efforts of the animals themselves to improve their condition—did not rest upon proved facts.

The study of paleontology and zoology had however established another conclusion, though it had crept in almost unnoticed. This was that animals had been destroyed by flood and famine, had fought with each other, and devoured each other throughout all past geological ages. Struggle, privation, ferocity, disease, and death had existed long before man began to be, and could therefore not be the result of any action of his. What then was the explanation of the perpetual contest causing so much suffering and destruction of life? Darwin answered this question by his discovery of the law of "Natural Selection," or the survival of the fittest in the struggle for life.

The story of how he conceived this idea and spent his life in accumulating such a mass of evidence as has convinced all practical naturalists of its truth is now well known. Since 1858, when he and Mr. Wallace together published the conclusion at which they had independently arrived, facts and generalizations confirming the law have accumulated at a marvellous rate. In details there is still much division of opinion, but these do not concern us now. Nearly two hundred years elapsed after Newton discovered the law of gravitation before Leverrier completed the analysis of the movements of the planets round the sun according to that law. In the far more complex world of life it would be idle to expect that all could be explained in thirty years. But even in this short time the theory of the evolution of the various living forms by the action of Variation, Inheritance, and Natural Selection has taken such firm hold on men's minds that not only naturalists and those who have studied the facts, but others who are quite ignorant of the origin of their convictions reason from evolutionary principles every day in theology, history, and other branches of knowledge, just as men reason from the theory of gravitation without being conscious of so doing.

The law of the Survival of the Fittest rests upon three undoubted facts. (1) Living creatures multiply so rapidly that there is neither room nor food for a thousandth part of them, and immense numbers die without ever coming to maturity. (2) Every living being born into the world varies slightly from every other; no two beings were ever exactly alike in all particulars. (3) All living beings inherit more or less the peculiarities of their parents.

Now, as the first of these facts is that countless numbers of beings must perish when young, the question arises,—what is it which decides which shall live and multiply, and which shall be crowded out and die? Darwin's conclusion was that the selection of those which shall survive is made by the sharp struggle for existence between all living forms. The plant which can best withstand frost or drought, or protect itself against animals which would otherwise feed upon it; the animal which can best hide itself from its enemies, or live longest without food, or travel great distances to find it, or which can best defend itself against other animals, or overcome them and prey upon them: these will survive and transmit their superiority to their descendants while others languish and fail.

So nature selects those living beings which are best fitted for their surrounding conditions, and any being which varies, however little, in a way which gives it an advantage, or inherits such a variation from its parents, will have a better chance of surviving and passing on this variation to its descendants. It is by this process that variations are assumed to have been strengthened and accumulated, till in the course of ages the numerous different forms of plants and animals have been produced. Such is the broad outline of the law of Natural Selection and its action in causing the evolution of living forms. Let us now see what we gain or lose in moral teaching by the discovery of this law.

It is wondrously strange that one of the most violent objections offered to Natural Selection has been that it makes pain and struggle the foundation of all the varied forms on the earth. But the pain and the struggle have existed ever since life began! The presence of suffering and evil in the world is the one mystery which oppresses all men, and against which our nature revolts so vehemently that we feel as if we could not wait till the slow unfolding of the future shall give an explanation of it. The Greek tried to solve the problem by assuming that matter had an independent existence, and that the Creator had done the best possible with a stubborn material. The Persian looked upon creation as the work of two rival powers, one good and the other evil. The Jew, having arrived at the conception of one Deity, attributed evil to the fall of the angels and man. All three left the difficulty as great as they found it, for no solution can be satisfactory which does not go back to one Eternal Omnipotent First Cause, the origin of the whole universe, and therefore of the nature of matter, angels and man alike.

In truth, neither science, philosophy, nor theology can furnish a solution, for if we are thoroughly honest and logical, we must confess that terrible as are the suffering, the disease, the grief, the misery, and the evil passions which exist to some extent in all life, they must belong to the scheme of the universe. To attribute them to any other power than the one First Cause is to suppose that some other cause exists independently. This at once makes each of the two powers finite and conditional, and necessitates another power behind as the First Cause of both.

The only point upon which the mind can really rest is the one Universal Omnipotent Power [1] "transcending intuition and imagination," to which we can assign no limits and no conditions, and to which we must refer every event and tendency in the known universe. Of all events therefore which seem to us either evil or good, we can only say that they form part of the will of the Universal power, and it is our own ignorance and extremely limited experience, and not some cause independent of Omnipotence, that we must accuse of the feeling of despair caused in us by the misery around us.

Far, however, from Natural Selection having introduced pain and struggle into the plan of life, it does slightly lift the veil of this terrible

[1] That there is one spiritual self-conscious being, of which all that is real is the activity or expression; that we are related to this spiritual being, not merely as parts of the world which is its expression, but as partakers in some inchoate measure of the self-consciousness through which it at once constitutes and distinguishes itself from the world, that this participation is the source of morality and religion; this we take to be the vital truth which Hegel had to teach.—T. H. Green, *Miscellanies*, p. 146.

mystery by affording us the first glimpse of a useful purpose served by them. If the different species were created once for all in their present form, the constant multiplication of beings only to perish while immature has no meaning. The young plants stifled by their fellows, or eaten off before their tender shoots can grow; the insects destroyed at all stages by birds and insect-eating mammals; the young birds themselves destroyed by storm or flood, or falling victims to birds of prey, the herbivora wounded and destroyed by the carnivora; and these last perishing by flood or famine, or by disease caused by parasites feeding upon them—all this round of suffering, with its terror and agony, such as a mother-bird feels for her threatened brood, could be attributed only to the wanton prodigality of nature "red in tooth and claw."

But if Natural Selection is the law by which all the varied forms have been developed, then at least we see that these unsuccessful lives have not been in vain. They have served a useful and noble purpose, for they are the material out of which natural causes have selected those best fitted to fill the world with living beings, adapted to the full enjoyment of life so far as their structure permits. For if every nook and corner of the earth is teeming with seeds, and eggs, and young beginnings of life, only waiting for a chance to start up and grow, it follows that every living thing must strive to the utmost, and utilize any spot in which it can succeed and escape destruction from others. Some, driven from the land, have taken refuge in the seas and rivers, acquiring in the course of ages a suitable bodily structure; others conquer the air; others the depths underground; while in all we can trace varied and marvellous instincts developed by the long education of necessity. And then, as the struggle goes on, instinct glides insensibly into intelligence, and among the higher animals each race, out of its own peculiar struggles, difficulties, and successes, develops the faculties of memory or attention, imagination or reason, or the emotions of affection, jealousy, suspicion, gratitude, fidelity, and veneration. Finally, in man the brain becomes the paramount controlling organ, and success in life falls to those who inherit courage, talent, perseverance, or any of the other qualities which in one way or another give them an advantage in the battle of life.

It is this purpose which the many dormant, stunted, and unsuccessful lives have fulfilled in the history of our planet, whether among plants, or animals, or the human race, if the theory of Natural Selection be true. And though this does not in the least explain why, in a scheme emanating from Omnipotence, individual suffering should be the stepping-stone to all happy and varied existence, yet when we reflect that our world is but a speck in a vast universe, governed by unswerving law, and tending we know not whither, does not the mere fact that in our own immediate sphere we have only *now* discovered a useful purpose in that which before appeared positive evil, lead us to trust that even in individual suffering there may be a truth higher than we yet know? If one "partial evil" proves to be "universal good" in our infinitesimally brief experience, does not the onus of proof that any evil cannot have its purpose, rest with those who make the assertion?

And this brings us to the logical conclusion we must reach if evolution is to be of any service in affording us a groundwork of morality; and this is that man also is the outcome of evolution and of the working of natural laws. Nearly all naturalists are now agreed that if the different species of animals have been gradually produced by ordinary reproduction from other species man cannot be an exception. His body is formed in all its parts like those of the higher mammalia; his muscles, nerves, and blood-vessels, his internal organs and his brain, are constructed on the same model, perform the same functions, and follow the same laws as theirs. He is affected by many of the same diseases, which he can actually take from animals and communicate to them, while their blood infuses fresh vigor into his, and even their nerves and muscles have been successfully grafted upon human beings to replace morbid portions in cases of disease. Nor is this all; animals and man have in common intelligence, memory, imagination, and even reason, as countless observations have shown, since attention has been called to the powers of the higher animals. They evince the same emotions of love and hate, fear and courage, a desire for revenge, and a power of self-sacrifice for their young, and even often for the maimed and helpless; and though these faculties are less developed in even the highest animals than in man, yet the difference is one "of degree and not of kind."

If it were not for a certain shrinking which man feels from being classed with his humbler companions, surely no one would hesitate to acknowledge the physical connection between them, and this shrinking arises from that curious incapacity we have noticed before to realize that *all* is the outcome of the First Cause. If the three great factors which we recognize in the universe—Matter, Energy, and Life—all emanate from God, why need we concern ourselves because we cannot define the origin of each, nor discern in what sense they are but different manifestations of one and the same mystery? What can it matter to us in what particular manner our body and faculties have originated, except that we should arrive at the truth concerning them as far as our limited powers permit? No doubt it *does* concern us very much to recognize that our faculties have reached a point infinitely beyond those of the lower animals, bringing us nearer to the higher attributes of the Great Intelligence from which we spring. But if we grant the evolution of animal forms at all, we must allow that vast powers of perception and sympathy have been developed in the dog which did not exist in the jelly-fish; why then should we feel any degradation in claiming kinship with the faithful dog because we have risen so far above him?

On the contrary, this kinship affords us exactly the basis we want for studying the rules of moral conduct. We have seen how, in astronomy, we have been able to arrive at great certainty in the working of law, because the problem is simple as compared to that of life. In the same way the laws governing living beings will be simpler, the lower the forms we study, especially if we begin with plants, in which they are apparently almost as mechanical, though on a different footing, from those of inorganic nature ; then, having gained even a rough outline of the instincts developed by evolution, we shall see how these apply to the conscious actions of animals, and these again to the infinitely more responsible actions of self-conscious man. I think, in spite of much that is perplexing and incomprehensible to our limited understanding, we shall find the results very far removed from that doctrine of selfishness and cruelty, of which the theory of Natural Selection has been accused ; and, moreover, we shall learn that the high moral instincts and duties which all religions inculcate have their elementary roots deep down in the sub-soil of life.

CHAPTER III.

"Flower in the crannied wall,
I pluck you out of the crannies;—
I hold you here, root and all, in my hand,
Little flower—but if I could understand
What you are, root and all, and all in all,
I should know what God and man is."

TENNYSON.

SO writes one of our greatest living poets, and in these lines we find the answer to the second half of the question at the head of our first chapter, "Can the herbs' virtues mine increase?" for to "know what God and man is" would be the solution of the whole matter; and even with the imperfect knowledge we now possess we shall find that the study of vegetable life does strengthen the principles which may guide us in the conduct of our own.

Not that we can attribute morality of any kind to beings so purely mechanical as plants, that we feel at once would be absurd, and it would be equally so to try and derive the foundations of our own moral sense from them, since, immediately above the very lowest forms of living cells (which can scarcely be classed under either kingdom), the two lines of plants and animals divide, never to meet again. Plants settle down to a stationary life and employ themselves in manufacturing food out of inorganic matter; and animals, feeding on the nourishment which plants provide, take the road through active moment to sensation and consciousness.

But we are now in search of the *laws of life,* and plants are living beings. The active matter, or protoplasm, which works in a plant cell is the same as that which forms the white corpuscles of our own blood, and just *because* plants have no consciousness or moral sense, we can the better study in them the general laws common to all life. Indeed, we shall find that in many points they strangely resemble ourselves, and people who have not studied the subject will be surprised to learn how these passionless beings injure or benefit each other, showing that the bright and dark threads which we call good and evil, are woven into the very fabric of life itself.

The end and object of plant life is fully expressed in the words "increase, multiply, and replenish the earth." Every one knows how crowded a hedgerow or meadow is with plants, or a thicket with bushes and undergrowth; and if a small clot of earth be taken from under any of these it will be found full of seeds, as Mr. Darwin has shown. He relates how he took a ball of dry earth weighing six and a half ounces from the dried leg of a partridge, which had been kept for three years, and when the earth was moistened no less than eighty-two plants sprang up from this small lump.

This example serves to give us a slight conception of the myriads of seeds which are waiting everywhere, and the most passing examination in the springtime will convince us how thickly they start above ground. No sooner do warmth and moisture reach the seed than the germ begins to sprout, and struggles on till the more weakly are cut off from one cause or another, and all but one or two perish. Even among the lowest forms of life we can see that it is the *effort to live* and not the preservation of any particular life which is all-important. Hence arise the rivalry, the struggle, and the selection of those which succeed best in overcoming the difficulties by which they are surrounded. At first it seems almost impossible that this can have given rise to all the countless varieties of plants and flowers, yet if we consider the varied conditions existing all over the earth's surface, the different climates, altitudes, and lengths of day and night, the deserts, forests, plains, mountains, and valleys, the different animals which attack plants, from mammals to insects and grubs, and the contest between plants themselves as to which shall hold the ground and live, we see how they must have assumed different forms if they were to exist and spread.

These conditions would determine the growth of the plant, the shape of its leaves and branches, and its manner of life. But there is another equally important fact, namely, its reproduction, and the formation and protection of the seeds from which new plants are to spring. Here too climate has to be reckoned with. The tender ovules and pollen must be protected from heat or cold, rain or dew, and from violent winds, and we find the shapes of the flowers adapted in various ways for this purpose. But the chief cause of variation has been the necessity for cross-fertilization, for all flowers require to receive pollen from time to time from others of the same species. For this service, plants, being stationary, are dependent on the wind and on insects, and it is to the methods they have adopted for attracting insects useful to their blossoms, and keeping off those that are hurtful, that we owe the lovely forms and the beautiful colors of their flowers.

Even in the lowest sea-weeds and fresh water algæ we find cross-fertilization from plant to plant going on in the water ; while, on the land, among pines and firs and some of the higher plants such as the hazel-nut and willow, the wind carries the pollen. But the remainder of herbs, shrubs, and trees are dependent on flying insects, which visited them in the beginning no doubt to feed on the pollen, then to suck the sweet juice secreted in various parts, and at last to gather the honey which the flowers began to lay up to attract them. So through long ages insects and flowers have worked upon each other, and any one who cares can now trace for himself in the works of Darwin, Wallace, Asa Gray, Müller, Lubbock, Grant Allen, and others, the proofs of the undoubted fact that it is the insect which has unconsciously turned the world into a "boundless flower-garden ;" and that as plants owe their general form to the struggle with the climate and each other, they owe their flowers to their rivalry in attracting insects.

One of the first results of this active competition has been that thrift and perseverance are strikingly developed in plant life. Each plant must seek and use all it can find.

Annuals, with their thread-like roots, utilize the surface of the soil and hasten to grow, to flower, and to seed during the summer. They live just on the limits of respectable subsistence, storing in their seeds only enough to start the next generation. Therefore they die after a few months, and at all seasons are liable to be cut off by frost or drought, as hard times kill the poor and scantily-fed among men. Yet they flourish in great numbers because they live without the depth of soil required by more lasting plants. They can also take advantage of a brief warm season to run through their whole life, even in places where a long, cold, cheerless winter fill two-thirds of the year, for though in such climates they grow stunted and weakly, they flower and form their seeds. Again, they can utilize the short moist periods in arid countries, and leave their seeds to sleep during the droughts. In a word, their wants are few, and they can seize opportunities not open to those which require more. A whole chapter of life might be written comparing these annuals with the lives of those among human beings who live from "hand to mouth."

Biennials take deeper root ; they store up food the first year and only flower the second year when their nourishment is secured and then die. By their greater providence they can withstand seasons in which annuals perish ; they provide stronger sustenance for their seeds ; and their roots and leaves produce a large proportion of the food material upon which animal life subsists ; but they require deeper and better soil, and may be compared to those among human beings who provide comforts and better life for their children, though passing on no store for the future.

Perennials also take one year for green growth only, then they flower sparingly even the second year and go on increasing their stock in hand, so that as herbs, shrubs, and trees they live for years and even centuries and found families ; for new branch-buds start and grow each year on the old stock, though, if struck off and planted, they become in themselves perfect plants. The world would be ill provided with vegetation without the rapidly-maturing annual, the food-producing biennial, or the store-accumulating perennial which can withstand vicissitudes to which the others succumb. Here too is a lesson for man.

Thus the effort to live, controlled by the same effort exercised by all life around, drives each plant to work perseveringly for food, to utilize every inch of available ground and opportunity, to seek the light, to provide its own defences, and to make its own friends ; and any plant which fails to do this is cut off by those which are more successful.

And side by side with these food-making plants live the *fungi* (mushrooms and toadstools) which have lost the green coloring matter and cannot make food, but take it from decaying plants or animals. These plants are often wrongly despised ; their advantage is that they can live in dark dank spots ; their use is that they act as scavengers, breaking down the hard tissues of rotting tree-trunks and dead vegetation and building up tender cells which soon dissolve and afford manure to young seedlings in the spring. They are the natural result of the struggle for life driving plants along any new path open to them.

So too are the smaller fungi, the moulds and mildews, which, however, fall below the limits of respectable subsistence and give us the first glimpse of mischief workers, for they prey upon their living neighbors. As smut, bunt, mildew, potato-fungus, and others, they grow within seeds or on leaves, roots or stems, filling the grains of wheat and oats with disease in damp sunless seasons, eating away the leaves of the hop, the vine, or the mulberry. Their germs are always ready to develop whenever unhealthy conditions of climate or soil favor them, and there is scarcely a plant which does not at one time or another fall a victim to their ravages; while, in other forms, they set up diseases in insects, fish, mammals, and even in man himself.

Such parasites answer to the debased and criminal classes among men. Driven by the stress of life out of the happy useful world, they prey upon others, weakening and hindering them in their effort to live. They have their counter-part too among higher plants, just as dishonest and unscrupulous adventurers are found in good society. The Dodder, a plant which attaches itself to thistles, oats, flax, hops, and other plants, and then decays at its root and feeds upon them, is one of these; another is the Broomrape, or Root-cancer, which feeds on the roots of the broom and gorse. Both these forms flourish in our latitudes; while in the tropics there are the Balanophores and Rafflesias, and the huge creepers in the forest, which suck the sap out of strong trees, and strangle them as they climb up to bloom in the light above.

We can view these depredators dispassionately in the plant-world, for we see that they arise simply by the natural efforts of plants to grow wherever opportunity offers; and even they may have their use, for in many cases it is the more weakly plants which become their victims, or those which from age or other conditions are nearing decay. The vigorous healthy plant, neither poorly-fed nor over-bloated with nourishment, will often resist the attacks of mildew or smut when others by its side fall victims. Thus, though positive evil-workers to the individual, these parasites may be instruments of universal good.

Be this as it may, however, there is no doubt that to themselves their life is debasing. As a fact we find that, with the exception of those which belong originally to the very lowest forms of life, they are always stunted and degraded types of the families from which they spring. The Dodder loses its true root and thrusts mere suckers into the plant it strangles; it bears no leaves and has only a wiry stem and small flowers. The Balanophores and Rafflesias have fallen even lower, almost to the structure of fungi, except that they bear flowers. The Balanophores, living on the roots of trees, are mere fleshy lumps, each bearing a spike of blossoms, and the Rafflesia has lost even its stem, becoming nothing more than a gigantic putrid-smelling flower. Here, then, we find the absence of healthy effort leading to self-degradation even in unconscious plant-life, showing that when a being ceases to be useful and industrious, and exists entirely as a burden upon others and hurtful to them, it becomes degraded itself, and is at war with the whole better balanced world. Thus the dark thread of evil appears as the converse of the healthy struggle out of which higher forms arise.

For when we turn from these baneful forms to vigorous vegetation we find that the interaction of plants with each other, and with animals, is so intimate that there are none which, in fulfilling their own life, do not do something for the good of others. Let us consider the case of self-defence. A plant grows thorns or bristles, or secretes a bitter poison to save its leaves from being devoured, but in so doing it secures its own growth, and not only purifies the air but bears flowers in which insects find pollen and honey. More than this, the very same organs of a plant often serve both for defence against foes and for guidance to friends. The bristles and hairs on a flower stalk, or even in the flower itself, which prevent wingless insects from creeping in and stealing honey without carrying pollen to other flowers, also serve as *path-finders*, guiding flying insects along the right road to the hidden nectary, so that they necessarily rub themselves against the anthers or the stigma on their way. Numerous cases of these path-finders occur among the Labiatæ (deadnettles and their allies), the Centaureæ (corn-cockles), and in the Scrophularinæ, (fox-gloves, and mulleins).

Another device for attracting as well as repelling is found in the strong oils secreted in the petals of flowers which serve both as distasteful flavors to keep off grazing animals and as scents to attract bees or moths ; while an example of mutual benefit occurs when low-growing trees and bushes, especially if they are prickly or distasteful in any way to grazing animals, form a protection for annuals and small plants which grow under them, at the same time that they shade them from the scorching heat of the sun. These small plants, on the other hand, help to keep the ground moist around the tree roots, and their leaves decaying every year form manure which is washed down into the soil.

Endless examples such as these of protection and assistance, both between different species of plants and between plants and insects, will occur to the reader when once his mind is directed to them. But these will serve to show that although the laws of life are undoubtedly stern, and each individual must strive for its existence, yet mutual help is a great factor of success even among plants. We actually find them using persuasion toward their pillagers, as in the case of the bush-vetch (*Vicia sepium*), the wild cherry (*Prunus avium*), and numberless others which have nectaries in their leaves to tempt ants and other creeping insects to seek honey there, so diverting them from the flowers which they would injure. Again they offer many tempting invitations to their friends in the shape of fruits, as when, for example, the plum or the cherry provide a luscious feast for birds, in order that they may carry the stone away and drop it in a new place to grow. Another remarkable example is the nutmeg of which the fruit bursts open on the tree, exposing the bright red-colored mace surrounding the seed. This mace is a bait for pigeons, which delight in it and swallow with it the nutmeg, which passes undigested through them, and finds a fresh home in which to germinate.

A still more striking instance of hospitality, this time with a view to protection, was observed in Nicaragua by Mr. Belt, where small stinging honey-eating ants live on a plant called the bull's-horn thorn. This plant bears thorns which are soft and full of a sweet pulpy substance when young, and upon this the ants feed, while they bore a hole in the coating of the thorn for entrance and exist. By and by the thorn, now hollow, hardens, and in it they live and rear their young, sipping the honey which is secreted at the base of each pair of leaflets, and feeding upon a little yellow fruit-like body growing on the leaves. These yellow fruits ripen one after the other, and so the ants are kept running over the young and tender leaves. Now, why should this plant feed and shelter a whole army of ants? Simply because it has very dangerous enemies in the leaf-cutting ants and grazing animals which destroy its foliage, and by affording shelter and food to these sharp stinging ants which throng out in numbers directly a branch is shaken, the shrub is protected from attacks.

This one case, which has been established, may afford a clue to many others where ants and insects of various kinds inhabit parts of plants, without doing them an injury; for investigations into these questions are still quite in their infancy.

Meanwhile, do not such examples as these show that life is not a mere selfish warfare, but that mutual help and service are among the very laws of existence, and that the truly fittest to survive are those who, in working for self-preservation, promote also the good of others? This is still more clearly seen in the mutual adaptation of plants and insects; for flies, butterflies, moths, beetles, and bees all visit and help to fertilize flowers, and in each case there is some special adaptation of the insect to the flower, and the flower to the insect which visits it. The size of the fly, the length of the proboscis, the weight of the insect, the manner in which it enters the flower, the rapidity with which it flies from one plant to another, are all-important; as are also the position of the honey in the blossom, the time when the stamens ripen, the hour of the day in which the flower opens, or at which it gives out its scent, besides all the marvellous contrivances for conveying the pollen to the proper part of the insect, so that it may reach the stigma of the next flower it visits.

The butterfly can reach to the bottom of a tube inaccessible to the bee, the humble-bee can weigh down petals and obtain honey or pollen which the little honey-bee is too light to uncover. Moreover, we find that bees visit many more flowers, and also flowers of more complicated structure than other insects. Why? Because the gathering of honey has become the work of the bee's life, therefore it is the insect most useful to the flowers So plant and bee have developed together, those plants surviving whose flowers by degrees hid their pollen or their honey most skilfully from vagrant insects, yet leaving always some clue by color or marking to guide the bee; and the bee little by little quickening in intelligence, because those which found their way best to the most useful flowers would both flourish themselves and propagate the plants which yielded them their food.

Even here we, however, have examples of the balance wavering between usefulness and mischief-working. Many humble-bees and beetles try to gnaw their way through flowers to the honey, when they cannot enter from above; and small creeping insects, as we have seen, find their way through cracks and crevices. Then at once antagonism and defence are provoked, and those plants survive best which can circumvent marauders.

Some flowers like the Campions (*Silena inflata*) have the calyx inflated so that the proboscis of the bee cannot reach the honey after it has gnawed a hole; others, among which the Proliferous Pink (*Dianthus prolifer*) is a striking example, have their calyx and bracts stiff and hard, so that they cannot be bitten. In others, again, sticky glands, and hairs on the flower stalk, are common protection against creeping insects; as in the sticky Lychnis (*Lychnis viscaria*), from one flower stalk of which Professor Kerner collected sixty-four small insects,[1] and in the Clammy Groundsel (*Senecio viscosus*), which has a dense covering of exuding hairs, through which creeping insects cannot pass without becoming imbedded in the slime.

Thus, we see aggression at once met by antagonism ; while attempts to appropriate the savings of others (namely, the stored honey), without rendering service in return, are defeated even in mechanical plant-life by all kinds of devices, the very attack actually bringing about the defence, by destroying the chance of the fertilization and production of young of such individuals as are least protected.

Lastly, in some cases, the effects of taking food without giving an equivalent recoil on the insects themselves, and we have a curious illustration of defence becoming aggression. We have seen how, on the viscid lychnis, dying insects were found, held there by the gummy secretion which keeps them away from the flower ; and the spurges protect themselves in a similar manner by a thick white fluid which oozes out of the stalk when it is pierced by an ant's claws, thus making him a prisoner. Other plants, such as the Bromelias, keep creeping insects at bay by a stiff rosette of leaves near the ground, forming a cup which holds rain and dew, in which the intruders are drowned.

So far the plants only protect themselves. But the Mountain Butterwort (*Pinguicula alpina*), the Sundews (*Drosera*), and Venus's Fly-Trap (*Dionœa muscipula*), have glands on their leaves which not only hold the insects, but digest the juices of their body for food. Again, the leaves of the Side-Saddle flowers (*Sarracenia*) of America, and the Pitcher-Plants (*Nepenthes*) of the Indian archipelago have been converted into buckets, or pitchers, holding water in which the victims are drowned and their juices digested by glands lining the pitcher.

Here we have the tables turned with a vengeance, plants feeding on animals instead of animals on plants, and as this is our first example of animals killed for food, let us pause to consider what it implies. Some would call it cruelty and liken it to the creation of disease by parasites. But be not too hasty. To be crippled and disabled in the work of life, we all allow to be an evil ; since an unhealthy being, whether plant or animal, is at a disadvantage in the struggle for life. But death, which ends this struggle, cannot be regarded as cruel, for the *healthy development* and not the *duration* of any one life is the important point. "Death," said Socrates, "cannot be an evil, since it happens to all men." He might have said, to all living beings, and since the very existence of such an immense variety of creatures depend upon their feeding one upon the other, this universal law of life cannot be a wrong, nor even an evil, except so far as suffering accompanies it.

There remains still another feature of plant-life which, fanciful though

[1] *Flowers and their Unbidden Guests*, p. 53.

it may appear, is yet worthy of notice. This is the sacrifice to some extent of certain individual blossoms for the good of the whole group of blossoms, and therefore of the plant.

We all know that some small flowers, such as the Hemlock and the Elder-blossom, are grouped thickly together in one inflorescence, so as to produce a mass of white or other color; while in the Thistle, Dandelion, and Scabious this is carried farther—a number of florets, each a perfect blossom forming its own seed, being crowded into one dense flower-head. The object of this is clearly to make the flower conspicuous and attract insect visits, so that pollen may be brought to many florets, and a large number of seeds formed.

Now a flower-head becomes much more conspicuous when the small tubular flowers are surrounded by a crown of large petals, whether white or bright colored, as in the daisy or dandelion. This advantage has led some plants such as the Viburnum or Guelder-Rose, the Knapweeds, the Sunflowers, the Bur-marigold, and others, to give up forming seed in the outer florets, and to use the material in growing large petals striking to the eye. Thus these florets are deprived of their natural function in order to increase the fertility of the inner ones, and in so doing strengthen the whole community.

As we have said before, it would be manifestly absurd to call this self-sacrifice when speaking of the mere adaptation of the flowers of a plant to its welfare. Yet it does show that the laws of nature recognize every variation which tends to the better success of the individual or the community, by Natural Selection rigidly weeding out those which are less successful; and though this seems a very unimportant modification in plants, yet when we come to consider insects, we shall find that purely structural changes of the same nature (see p. 30) do lead through natural selection to the development of such a noble trait as self-devotion.

And here we must end our very brief sketch of plant-life, content for the present with having suggested a few pregnant thoughts, and learned one great lesson—namely, that among plants injury to others calls forth opposition, and recoils upon the injurer; while, on the other hand, those succeed best who, in fulfilling their own life, also compass the good of other beings. Thus, through struggle and mutual help, has come to pass the development of highly organized, beautiful, and wonderful forms even in the plant-world. And we must remember that this has not taken place by special guidance along certain beneficient lines, since degradation and partial deformities result as by products of the struggle for life; but that the overwhelming preponderance of healthy, happy, and varied existence has been brought about by the steady working of natural laws among which the struggle to survive and the constant action of natural selection are the most important. Can we question that here we have a foundation never to be shaken by any change of opinion or dogma?

CHAPTER IV.

"How wonderful! that even
The passions, prejudices, interests
That sway the meanest being, the weak touch
That moves the finest nerve
And in one human brain
Causes the faintest thought, becomes a link
In the great chain of nature."—SHELLEY.

FORTIFIED now by two general conclusions,—that life works by definite laws, and that, in the struggle for existence, self-preservation and mutual help work hand in hand,—let us turn to animal life, in which the problem is much more complex. For, in the first place, the mere fact that even the lowest animal forms move in search of food, makes us assume *purpose* in their instincts where we have only recognized mechanical action in plants; and secondly, as the great naturalist Huber remarked, "a little dose of judgment or reason comes into play even in animals low in the scale of nature."

We can no more decide at what point this new element is developed, in the ascending scale of life, than we can tell when a child begins to think. But we cannot doubt that such creatures as an octopus washing and tending its young, or an earwig gathering them around her as a hen does her chickens, do understand in some way what they are doing; and when we come to such insects as spiders, bees, and ants, we observe that they hesitate, choose, and decide what they will do, and even recognize when they have made mistakes.

And together with this dawning of judgment and reason comes emotion, and these little creatures exhibit anger, jealousy, curiosity, playfulness, caution, and fidelity. No one can doubt that an ant has at least an instinctive perception of its duty, so to speak, to the community; that workers show courage when they fight to the death for the cocoons under their care; or that the robber-bees creep stealthily into the strange hives, quite aware that they will be killed if detected. Yet blind instinct still holds these insects with a firm grasp, and they perform their duties far more mechanically and unerringly than even the lowest of the vertebrate animals; therefore, we shall do well to glance at them before we pass on to what more immediately concerns us.

As in plants, so in insects, to feed and multiply is the main object of existence, and the peculiarities of their structure can all be traced directly or indirectly to these necessities, though very much complicated by the number of different stages in their lives as larva, chrysalis, and perfect insect. In the first stage, feeding is their whole life ; in the second, those which become quite still must find protection during their sleep ; and in the third, feeding and egg-laying, going hand in hand, have led to the greater part of the marvellous adaptations and defences of plants and perfect insects.

The feeding stage need not occupy us long, except to glance once more at the curious fact of parasites. Insects multiply at an almost incredible rate, and though no doubt in early geological times, when the cricket and the centipede fed in the forests out of which our present coal was formed, plants were their only food, yet soon the pressure of life drove some, such as dragon-flies, to feed upon others ; others, such as beetles and wasps, to devour decomposing matter, acting as scavengers ; while out of almost every family of insect life some are parasites during the first part of their existence.

And here we find the same lesson as in plants. Any grub or caterpillar, which comes from an egg placed by the mother inside some other creature, is soft and of low structure, with no limbs, having no need for them. Yet when it emerges from the chrysalis state into that of an active being, which must seek its own food and a place to lay its eggs, the full-grown insect has wings, antennæ, and other parts delicate and beautiful. In some cases, however, as in the stylops (a parasite living on the humble-bees), the mother does not cease to be a parasite, but lives on, a blind, legless creature, giving birth to her young ones without ever becoming perfect herself.

All this is in accordance with the survival of the fittest in the struggle for life, for when driven to a torpid existence, sapping the life of others, it is a saving to the parasite not to develop parts it will never use, or to put them on only when bursting into active life. Yet at the same time it emphasizes the irrevocable law that *effort raises*, and *dependence lowers*, warning us, as rational beings, of the danger of drifting into helplessness and dependence ourselves, or of driving others into it either by our own greed or injustice, or by the indolence which induces many to bestow indiscriminate charity rather than take the trouble to help others to help themselves.

But this is anticipating. Returning to the insects, we find that, on the one hand, they have endless offensive devices for protection and attack ; as, for example, the nauseous taste of some caterpillars and beetles, protecting them from birds, or the bristles of the hairy caterpillar which serve the same purpose, and also prevent the ichneumon-fly from laying its eggs under their skin ; their constant movement making it difficult for her to insert the long sheath or ovipositor, through which she passes her eggs, into the bodies of her living victims. In like manner the horny covering of the weevils, the powerful nippers of many beetles, as, for example, the stag-beetles, the stings of bees, wasps, and of some ants, the strong fluid that the bombardier-beetle squirts back at its pursuer, are all modes of defence.

Yet, on the other hand, even among the lower insects mutual help is found. The dung-beetles (*Scarabæidæ*) will assist each other in rolling up the pellets of dung which they bury with themselves for food. Many caterpillars weave tents in common ; thus the caterpillars of one of the fritillaries (*Melitæa Cinxia*) join together and form a pyramidal silk tent, which shelters them from sun, rain, and attacks of birds. When they have exhausted the food near this tent, they move on and weave another ; and in the winter they make their shelter rounder and stronger, and lie heaped up upon each other, sometimes as many as a hundred together, till spring comes, when they separate, each to form its own chrysalis.[1] The processionary caterpillar does the same and these insects travel over the trunks of trees in long lines, a shock given to the first, passing all along the line as if giving warning. Lastly, in ants there can be no doubt that warning is given from one to another, and when any member is in danger the others are uneasy. M. Huber relates how, when he disturbed some ants which were drinking, one who had started away turned back and pushed and struck three others till he drove them home ; a fourth was restive, but in spite of his menacing jaws the other dragged him away by the hind-leg till he was in safety.

A study of the adaptations for self-preservation among the numberless forms of insects, will repay any student, who will watch nature carefully for proofs that survival of the fittest forms has developed in each type its beauty, its peculiarities, and its powers, creating all the wealth of the insect world ; while, at the same time, he will come across many unexpected instances of mutual help and protection.

The most important adaptations, however, as bearing on our present subject, are connected with the second great instinct of reproduction ; for this, which in plants has given rise indirectly to the beauty of their flowers, lies in animals at the root of the far more important qualities of love and sympathy.

In feeding, a creature supplies its own wants ; in multiplying and providing for its young, it labors for those "other-selves," to whom it will often sacrifice its life. It is in insects especially that we can best trace how a mother's care was at first a mere mechanical instinct, only a step above the protection of the seed in plants. For among all the lower insects the mother *does not live to see the eggs hatched.* Yet she will take great trouble and risk to lay them in safety, on plants quite different from those on which she herself is feeding, though it is true that during her early caterpillar life she was nourished upon them. Thus the common cabbage butterfly sips the blossoms of the flower-garden but goes among the cabbages to lay her eggs. The cockchafer, which, when flying, feeds on the leaves of trees, buries herself in the earth to lay, so that the grubs

[1] Kirby and Spence. *Entomology*, p. 301.

when hatched eat the tender grass roots. The dragon-fly lives on insects in the air, yet drops down on the leaf of a water-plant to deposit her ova, which yield grubs whose life for more than two years is spent at the bottom of the stream.

More wonderful than all these, the honey-sipping *sphex*, or sand-wasp, burrows a tunnel in a bank, lays her egg in a hollow at the end of it, paralyzes grasshoppers by stinging them at those points in their body where the nerve-cords meet, lays them alive yet motionless by the side of the egg and then closes the opening.[1] In this way she provides separate tunnels and food for several eggs, so that the grubs, which she never sees, find fresh food ready for them when they awake. All this is done so mechanically that a sphex, whose cell was emptied both of egg and food, after going in as usual and looking round, went on where she had left off and closed the cell *with nothing in it.* Yet so determined and earnest are they in their work that no danger or difficulty hinders them.

From an instinct so strong as this, it is quite natural that there should spring a tendency to watch over the young when the mother lives to see them ; especially as, on the theory of natural selection, the best mothers would rear the most offspring, and thus the tendency would increase. And, in fact, even among lower insects we find the cockroach helping her young out of the egg-sack, and the earwig hatching her eggs and gathering the young around her, as a hen gathers her chickens ; while the hunting spiders carry their egg-bags under their body, and will fight for them till death. One of these spiders *(Lycosa saccata)* not only opens the bag for her young to escape when hatched, but carries them upon her body and feeds them till they cast their first coat.[2] Then we have those solitary bees and wasps which form a home and store food for their family ; and lastly, the bee, wasp, and ant communities, where numbers are banded together for helpfulness and security.

And here occurs a remarkable feature peculiar to insects, yet teaching how, in the struggle for existence, self-devotion and self-sacrifice for the good of all have been developed out of the maternal instinct. For in the homes of bees and ants the workers are neuters or imperfect females, which never become mothers, and yet tend and watch over the eggs and cocoons of the young as if they were their own. They nurse them, clean them, play with them, and in the case of ants, lead them about the nest and educate them, and will risk their lives to protect them. Such naturalists as Huber, McCook, Forel, and others who have studied the lives of ants, can scarcely find terms strong enough to express their admiration for their industry, intelligence, and self-denying care of the nest ; especially in the case of the slave ants, carried away from their own nests in the cocoon, yet when full-grown, feeding, nursing, cleaning, and working for the species of ant which has taken them captive.

But what concerns us chiefly here, is that these communities teach

[1] Fabre, *Souvenirs Entomologiques.* [2] Kirby and Spence, p. 205.

us how, even among insects, co-operation, and some self-abnegation on the part of the individual have been developed for the good of all. We saw the beginnings of this even in the mechanical life of plants (p. 25), where the reproduction of some florets in the composite flowers was sacrificed to the general attraction of the flower for insects ; and now we find the same sterility induced in insects for the welfare of the whole community, while yet the working bees and ants show as great an attachment and devotion to the young as if they themselves were the mothers.

In the overwhelming pressure of insect-life it is evident that the solitary bee, such as the anthophora or the osmia, which has to lay the eggs, build the comb, store the honey, and nurse the young is, other conditions being equal, at a great disadvantage compared with a community in which the queen bee only provides the eggs, and the workers, stopped in their growth at the neuter stage, use the maternal instinct entirely for the good of the hive. And so true are these instincts of industry and devotion to the community that neither in the bee-hive nor the ant's nest is there, so far as we can detect, any leader or master to constrain each to do her duty. The long inherited habits induced by the survival of those mother bees or ants which gave birth to steady working communities, seem to be sufficient to keep all in order, though, as we saw when one ant wished to take the other out of danger (p. 28), it is possible for an ant to have "a will of her own."

Lest, however, we should rank these insects higher than they really are, we must note here a strange fact which has also its significance. Among nearly all the forms of lower life till we come to vetebrates, the *father* does nothing for the young ; his use is purely to fertilize the egg-laying mother. When this is accomplished, the males and many of the females among ants die in the open air, destroyed by rain or devoured by birds, and the females which survive pull off their wings and return to the old nest or found a new one. Among wasps the males are more useful, for they act as scavengers, sweeping and cleaning the passages of the nest ; but as wasps lay up no food for the winter, the males and workers all die off as the cold season comes, leaving only a few queen-wasps to start fresh communities in the spring.

Among bees, however, an apparently cruel scene takes place, for as winter draws near the workers turn the males or drones out of the hive and sting them to death. The reason for this is clear. In winter food will be scarce, no idle mouths can be fed, and the drones never work, and are many in number. They have become, in fact, though from no fault of their own, a burden on the community, and as such are destroyed. Probably the speedy death is more merciful than the slow starvation among wasps, yet this wholesale destruction of fellow-citizens reminds us that individual sympathy belongs chiefly to creatures higher in the scale of life. In insects the instinct of self-preservation reaches its utmost development in the preservation of the community, and personal affection for special individuals is rare.

On the other hand we can observe among insects the evil side of self-interest in the form of selfishness and self-indulgence appearing side by side with self-devotion. From time to time among bees robberies are committed on other hives, sometimes by solitary bees, sometimes by an army, which enters a neighbor's community to steal the honey; and when this happens on a large scale, the robber bees become regular marauders, collect no honey of their own, and often destroy a whole bee-stand. Ants, too, have their wars, sometimes for a disputed plot of ground, sometimes for the possession of the aphides or plant-lice, which yield the sweet liquid the ants love so much, and to obtain which they will even tend the aphides and keep them underground on the roots of plants as a milkman keeps cows in his sheds. Among certain species of ants sanguinary wars also occur for the purpose of making slaves; and here, again, we meet with the lesson of degradation following upon self-indulgence, for while the individuals of one species of slave-making ants have not yet lost all sense of industry, but work with their captives, those of another species (*Polyergus rufescens*) have become quite helpless and die from want of food when their slaves are taken from them. They only retain one useful weapon—their pointed mandibles, with which they fight when they attack a nest to steal the slave cocoons.

With the ants we reach the highest development of insects; and now when we turn back and start along another line—that of vertebrates—we find greater possibilities and promise of higher qualities from the very outset. For here intelligence, individual experience, and reason begin gradually to supersede fixed instinct; and, as each individual life becomes its own centre, creatures live in pairs or family groups, and the father now, for the first time, takes the position of protector and provider.

Even among fish the stickleback builds a nest in the water and coaxes or drives the mother into it to lay her eggs, which he defends till the young fish are strong enough to swim about and feed themselves; and among pipe-fishes it is the father who carries the eggs in a pouch till they are hatched. The young of the great pipe-fish, which lives in our bays and harbors, even take refuge when alarmed in the father's pouch after they have begun to swim about. Among amphibians the obstetric frog (*Alytes obstetricans*) takes the eggs from the mother, and twisting them in strings round his hind-legs carries them in the water till the tadpoles emerge. Among reptiles, however, we have no instances of paternal care, though the mother, both among crocodiles and snakes, often watches over and protects her young.

But when we rise above these cold-blooded animals to birds, the attention of the male bird to his mate or mates, and his care of the young, is often as true and steadfast as among the best of human beings. Not only do both birds, male and female, work together in preparing the nest, but in some birds, as, for instance, the puffin, the father digs the tortuous burrow about ten feet deep in the earth ready for the eggs. Among nightingales and other birds the father feeds the mother regularly while she is sitting, while in some cases, such as the dotterel and the ostrich, he often takes her place on the nest. All books on birds are full of touching anecdotes of the affection of parents for their nestlings and for each other, and any one who has ventured too near a brood of turkeys or geese will have learnt by experience that male turkeys and ganders can protect their young.

Moreover, as individual experience and education now begin to take partly the place of instinct, the father and mother together guide and teach their young. While a butterfly takes to the wing at once on leaving the chrysalis, and sips honey from the flowers without any need of example, the young birds have to be taught to fly, to find their food, and to recognize different dangers ; and when we remember how many thousands die in the early spring, we can understand how those will best survive and flourish whose parents develop the greatest amount of intelligence and affectionate care and devotion.

Therefore, we are not surprised to find that birds become social and form communities, either for seeking their food and migrating, as among field-fares, starlings, swallows and others, or for life, as among the rooks. It is among these last that duty to the community is probably carried to its highest point among birds. Thus rooks are known to place a sentinel to watch for danger while the rest feed, and if he fail in his duty he is judged and pecked to death. Young birds also, which begin by stealing twigs from others to build their nest, are soon taught a better morality, for several of the older birds unite to tear their nest to pieces till they do their own work honestly. On the other hand, rooks have been known to feed a blind or a wounded companion, and even to make attempts to release one caught in a snare.

One of the most touching instances, however, of devotion to a comrade is given by that very reliable self-taught naturalist, Thomas Edward, as occurring among the terns or sea-swallows, which live together in colonies, laying their eggs on the sea-shore, on marshes, or sandy shingle. Having wounded one of these birds on the coast of Banffshire, he relates: "I beheld, to my utter astonishment and surprise, two unwounded terns take hold of their disabled comrade, one at each wing, lift him out of the water, and bear him out seawards. They were followed by two other birds. After being carried about six or seven yards, he was let gently down again, when he was taken up in a similar manner by the two who had been hitherto inactive. In this way they continued to carry him alternately until they conveyed him to a rock at a considerable distance, upon which they landed him in safety.

"Having recovered my self-possession I made toward the rock, wishing to obtain the prize which had been so unceremoniously snatched from my grasp. I was observed, however, by the terns, and instead of four, I had in a short time, a whole swarm round me. On my near approach to the rock, I once more beheld two of them take hold of the wounded bird, as they had done already, and bear him out to sea in triumph, far beyond my reach. This, had I been so inclined, I could no doubt have prevented, but I willingly allowed them to perform, without molestation, an act of mercy, and to exhibit an instance of affection which man himself need not be ashamed to imitate."

Thus we see how, with quickened intelligence and social habits, affection and sympathy enter the life of birds, probably much more fully even than we can trace. Yet in them, as in mankind, we can also trace in many instances the instinct of self-preservation conflicting with that of self-devotion ; as, for example, when migratory birds have a late brood not yet fledged when the time arrives for starting on the autumn journey. In this case there are examples on the one hand of a mother leaving her young behind, and on the other of her staying to face the winter with them.

When from birds we pass on to mammalia, whose young are born alive and still more helpless, the necessity for care and attention to the mother while she is suckling and tending her little ones calls out more and more the instinct of the father to provide food and defend his family. So we find the males strong and powerful in the lion, bearing antlers in the stag, tusks in the boar, horns in the antelope and buffalo, while father and mother alike develop cunning and the necessary qualities for finding food and providing for themselves and their young. With courage, too, comes tenderness and affection for those protected, and with increased danger, increased intelligence and devices to meet it.

Thus when we reach the higher animals, such as the elephant, the dog, and the monkey, we find that the battle of life through long ages has developed in them, memory, imagination, and no small amount of reason and judgment ; and together with these the emotions of love and hate, courage and timidity, emulation and gratitude, suspicion and curiosity, and at any rate in dogs and elephants, the rudiments of what we call conscience, shown by a sense of shame when they have done a thing for which they have once been punished.

Instances of intelligence and affection among the higher animals are so well known that it is scarcely necessary to quote them. Every one knows how the lion remains with his family till the cubs are grown, protecting the mother and teaching the young to hunt, and also that most animals among the carnivora are excellent parents, though only wolves, wild dogs, and jackals, become social, and hunt in packs. Among the herbivora, on the other hand, where the animals have to defend themselves against the attacks of wild beasts, social life, and services rendered

[1] Smiles, of *Life of Edward* p. 240.

from one animal to another, are rather the rule than the exception. Rabbits, though timid and rather stupid animals, stamp with their hind feet to warn their comrades of danger; even sheep do the same with their fore feet, and an old ram will defend a flock from a dog. Beavers build their homes in common, each family living in a lodge with others close around it. Prairie-dogs, rats, and other rodents live and work together, and seals travel in large shoals and set sentinels to watch for danger when they camp on islands for the breeding season.

Among seals, however, family-life is more important than devotion to the community, and they are perhaps a striking instance how, among the higher vertebrate animals, the home-centre became the chief starting-point, family affection having been much more strongly developed than in insects or other lower orders. This may perhaps explain why in the human race the social mechanism has not even yet reached the perfection which we find in ant-communities. For in man deeper and more complex motives come into play, and the home-life has, as it were, to be reckoned with and widened, before such devotion to the community can arise as is found among the less sympathetic insects.

The courage with which the fur seal holds his position as the head and guardian of a family is said by the best authority, Mr. J. A. Allen, to be of the very highest order; he will defend his wives to the death, and also the pups so long as they remain on the spot he has chosen for the home. But if they stray beyond this boundary, neither he nor the mother seek them out, and it is the bachelor seals, those who have failed to obtain wives, who watch over the young pups and become their "jealous and fearless protectors" in the autumn when the fathers swim away.[1] Does not this last fact show incidentally how the emotion of affection once awakened craves to find satisfaction in animals as in man? Do not the fatherless seal, tending the deserted young ones, remind us already of many unsatisfied human lives which find their satisfaction in fulfilling the loving duties neglected by the more successful?

And, indeed, among the more intelligent animals we do find self-devotion in some of its most touching forms. The buffaloes putting the females and young in the centre of the herd and defending them against attack; the male baboon, which came down from the mountain in the face of the dogs to rescue a foolish young baboon scarcely six months old which had remained behind; the elephants, who placed a badly wounded tusker in their midst, and supporting him between their shoulders, succeeded in securing his retreat to the forest; nay, even the elephant whose master rode him carelessly through dead and dying natives in an epidemic, and who yet carefully picked his steps among the people so as not to injure them,—such instances as these are well worth recording, for it is a great error to suppose that man is lowered by proofs that dumb animals also show signs of nobleness of character.

[1] Allen, *North American Pinnipeds*, p. 356.

On the contrary, bearing ever in our minds that the laws of nature are the working out of the will and intention of the Great First Cause of all, we find a surer foundation for our own higher instincts when we see the manifold branches of life spreading ever upward from their unconscious root and opening out to greater and greater possibilities. And surely, as we watch one by one the nobler qualities developing, by the daily experiences and efforts of beings in the ascending scale of life during long ages, our hearts must thrill with an emotion akin to that felt by the patriarch Jacob, when awaking from his dream he exclaimed, "Surely the Lord is in this place, and I knew it not!"

For we stand above even the most noble of these lower animals in our power of reflecting on the past, and thus foreseeing what may happen in the future; and still more in being able to examine our own impulses and actions and to compare them with laws governing the outer world. It is this wonderful faculty, and not the mere power of choice or free-will upon which many lay so much stress, which raises us so far above the dog or the baboon. These can and do choose between different actions, and suffer when they make mistakes; but they lack, so far as we can see, that *self*-consciousness and mental power which enables us to look beyond the visible and material phenomena to the invisible laws which govern them.

And this it is which lays upon us so heavy a responsibility; that we can reflect upon our own being, upon the consequences of our actions, upon the problems of life, death, and eternity. Surely then, having this faculty, it behooves us to inquire very seriously how far our actions are in accordance with those laws which have been in force ever since the world began; and when we find that we are tending toward that degradation which we have seen to be the converse of the upward struggle, to mend our ways and strive that ours may be the healthy, vigorous rivalry which works good both to the individual and to all. How far our present study of the laws of life can guide us in this we must next consider.

CHAPTER V.

"A wise man will extend this lesson to all parts of life, and know that it is the part of prudence to face every claimant and pay every just demand on your time, your talents, or your heart. Always pay; for first or last you must pay your entire debt. Persons and events may stand for a time between you and justice, but it is only a postponement. You must pay at last your own debt."—EMERSON.

WE have now traced in a very general and imperfect manner the working of the laws of life in plants and animals. The outline is necessarily very rude, both because it has been given so briefly and also from the imperfection of our knowledge. Still we have established some general truths which we now can apply to the conduct of our own life.

The first of these, upon which all the rest depend, is the invariability and steady unswerving action of the Will of the Author of all things, as expressed in the laws of the universe. This world is not one in which, by chance or by solicitation, we can escape the consequences of our acts, or reap that which neither we nor our ancestors have sown. In inorganic nature we know that a flash of lightning travels according to definite electrical and atmospheric laws, whether it strikes the bare ground or a human being. The earthquake occurs in accordance with the conditions of the globe at a certain time and place, whether it disturbs a desolate plain, or destroys a populous city. In mechanical plant-life the weakly seedling, or one falling on barren rock, is destroyed by wind or weather, or stifled by other plants, unless it possesses some faculty of adapting itself and obtaining nourishment and support. In the animal world the creature which, from want of intelligence, from inheriting a weakly nature, or from some other defect, fails to find food and protect itself, will invariably be cut off in the struggle for life. And in man, hard though it may appear at first sight, the child who, through faults of its ancestors, inherits disease of body or mind, who, through bad training and surroundings, develops vicious tendencies, or through ignorance or want of judgment, loses his way in life, must pay the full penalty of weakness and mistakes. His only chance of escape is when, by the help of others or the effort of some faculty in himself, he can adapt himself to the conditions of life, as the trailing plant lifts itself to the light up some friendly wall, or the little black ant, taken captive by a stronger race, conquers it by industry, and becomes the true master of the nest in which it was a slave.

And this brings us to the point so often made an excuse for self-indulgence. If we are thus held so firmly in the grip of inheritance and training, how can we be responsible for our actions and our upward or downward course? The answer which science gives leaves us no loophole of excuse, nor does it oblige us to enter into the vexed question of free-will, which is as hopeless as the origin of life itself.

From the very beginning of animal life, we see a power of "choice" developing together with consciousness; till, in insects, we see ants even consult together and determine upon a line of action, while in the vertebrata, to which we ourselves belong, the governing power of adjustment in intelligent acts becomes still more marked. Any one who has studied animals must have observed that a dog will hesitate whether to follow his master, or stop to eat some tempting morsel; and the touching example given by Mr. Lloyd Morgan[1] of his favorite terrier, who turned to bite as his master sewed up a painful wound, but checked himself before the teeth closed tightly, and piteously licked the hand instead, shows how self-restraint may be exercised by animals. No doubt they will decide according to their nature and training, but decide they *must*, and they show that they exercise the power of choice. In the same way a drunkard who once excused himself to me, that he must drink, for he had inherited the tendency, could nevertheless not deny that the "choice" lay with him to take or refuse the glass; for, as I pointed out, the very fact that he could *recognize the tendency*, showed he had a faculty within to resist it—which he did, and became a sober man.

No doubt a keen discerner of character might predict which way this man would act according as he had a weak or strong will, and according to the force of the circumstances surrounding him. But the man himself cannot do so impartially, because in the very act of predicting he would be implicitly making a choice—namely, that of continuing, or relinquishing as hopeless, the effort to resist; and it is *effort* of all kinds which we see to have been of such paramount importance in the history of the evolution of living beings.

From the earliest beginnings of animal life upwards we see gradually dawning this power of choice, out of which responsibility springs. The higher the creature, the more personal experience and choice take the place of fixed mechanical instinct, till in ourselves the power of reflecting upon the consequences of our actions, and *remembering* how we have succeeded or failed according to our decision, brings a sense of right or wrong action, where, in mechanical instincts, we see only fitness or unfitness to succeed. Thus, as in obeying the laws of chemistry or of physics, man subdues them to his purpose, so in obeying the laws of life he succeeds in the struggle for existence, and the power by which he does so, like *all power* in the universe, emanates from God.

But now we find ourselves in the midst of a new order of things. Through long ages this power of intellect and moral purpose, strengthened and developed in the struggle of man with man, and man with nature,

[1] *Animal Life and Intelligence*, p. 340.

has drawn us, on the one hand, nearer and nearer to the Great Power, from whom we derive this higher life; while, on the other, it has become a fearful possibility for evil. The plant which saps the life of another performs a merely mechanical act; the ant which makes slaves follows a fixed instinct which it has inherited, and has no consciousness of degradation. The bird, whose instinct of self-preservation urges her to migrate and neglect her young, forgets them as soon as they are out of sight, and feels no remorse. The animal which gratifies the strong instinct developed through all nature for the purpose of reproduction, never thinks of the instinct again till the next occasion occurs. But man, remembering in all these cases the pleasure or the pain, the fitness or unfitness of his action, and deliberately resolving to repeat or to avoid the pleasurable sensation which is unfitting—to persevere in, or to neglect, the effort which is fitting—*works out his own development or degradation, and knows that he is doing so.*[1]

It is when we recognize this, and remember how all the forms of happy, vigorous life have sprung from the selection of those best fitted for their existence, that we begin to ponder how far we are fulfilling the conditions of our life, and to value the lessons taught by the working of natural law. These have shown us that the two great necessities of self-preservation and reproduction have led, on the one hand, to the effort of each individual to succeed, and on the other to a mother's care, extending gradually to that sympathy and devotion to others which becomes in ourselves a strong motive power, urging us to seek the good of the whole living world. It is in the balance of these two instincts—the duty we owe to ourselves, and the duty we owe to our neighbor—that the moral conduct of life consists.

Let us take the lower ground first and consider how a man who thinks only of himself is yet forced, if he wishes to succeed at all, to obey to a certain extent the laws of right and wrong, because they have their roots in the very foundation of existence. Does he wish, for example, to enjoy life? then he must keep in bodily and mental health. We see that if a plant is hurried on too fast to flower and seed before it has stored up strength, it grows weak and dies early. So a young man who uses up his life too fast, either by dissipation or by overwork and privation, unfits himself for the struggle of existence. But there is a difference in the two cases: by work and self-denial he *is* preparing for life and gaining on one side, even if he loses on the other by want of judgment; in dissipation it is *all loss*. Turning night into day for pleasures which are only for the moment, burning away his strength with intoxicating drinks, wasting his manhood by irregular passions, he is inevitably incapacitating himself for

1 For a more complete exposition of these arguments see Darwin's *Descent of Man*, chap. iv., in which the bearing of the struggle for existence upon morality was first laid down.

a long and happy life. Nay, even if he prefers a "short life and a merry one," he is on the wrong road, for he is reducing his power of enjoyment both bodily and mental. Each excess lowers his vitality, each immoral action debases his senses, while it, nevertheless, creates a craving for that which has ceased to be a pleasure, and he becomes less and less fit to survive in the struggle for existence.

Such facts as these force themselves even upon the most selfish; but when a man's actions are chiefly harmful to others, it is not always so obvious how they recoil upon himself. Yet if we consider a moment, we must see that if the self-regarding qualities of courage, strength, ability, power of endurance, industry, perseverance, determination, and self-control, are weapons with which we fight the battle of life, so too are the altruistic qualities of truthfulness, honesty, justice, unselfishness, gentleness, and sympathy; for he who exercises these last invites and obtains the respect and assistance of others, while he who fails in them raises up antagonism, just as the unfriendly visitors to flowers raise barriers against themselves by the natural survival of those plants which possess the best means of protection. How a nature devoid of true sympathy and of a sense of justice to others may succeed for a time and then fail, is well exemplified in the life of the first Napoleon. Without any of the grosser vices he yet sacrificed first individuals, then nations, to his ambition, until, having roused the whole of the civilized world against him, he, though probably a man of greater ability than any of his contemporaries, was isolated like a dangerous wild beast till his death.

Yet how few men realize the inevitable result of injustice, of scant honesty, of untrustworthiness, or even of a hard grasping nature which lends no helping hand to others. We cannot look around without recognizing that among those who work there are many who think no harm, for example, of exacting a full day's wage and idling so as to do only half a day's work; of selling adulterated food so as to make a large profit; of scamping work done by the piece, and passing by a flaw which may ruin the machine of which it forms part. Again, turning to men of property, how many, of otherwise upright character and good social standing, will not hesitate to start a speculation, in which they themselves may gain much if it succeeds, and lose little if it fails, which failure, however, would involve the ruin of many; or to take advantage of the pressure of life to pay starvation wages; or of a large command of capital to create a monopoly, by which thousands suffer, to increase the wealth of one. So long as they keep within the law, not a few men would laugh to scorn the idea that they are not right in getting all they can, and giving as little as they must.

True, the voice of religion has always been lifted up against such actions. But how, if men do not believe that the eye of a just God is over them, or that it is forbidden to "grind the face of the poor," or to take unjust advantage of others? The answer of science is that these commands of religion are not mere dogmas, but literal statements of the truth. The keen scrutiny of natural selection, the outcome of the laws of the universe which *are* the will of God, has never ceased to act since life began; and *imperfect and unfit work, whether in plant, animal, or man, renders that being less fit in the battle of life, while unfair advantage and hurtful actions toward the community create oppositoin which is a barrier to success.* The workman who slurs over his work, and the man who overreaches his neighbor, are challenging the world to protect themselves against fraud, just as much as the humble-bee, gnawing the calyx of the Campion, challenges that plant to protect itself by an inflated or horny calyx (see p. 23); and the law of Natural Selection will as surely cull out and uphold the workshop in which honest work is done, and the shop in which honest goods are sold, as it does the healthy and the vigorous in lower life. Nor is this all, for a country, in which trustworthiness and honesty are losing ground, will be at a disadvantage in the competition with countries in which the moral standard is higher; and as the country suffers, every individual suffers with it in the long run. Though "persons and events may stand for a time between you and justice, it is only a postponement. First or last you must pay your entire debt."

In like manner, the master who pays no heed to justice between man and man in the treatment of his work-people, or heaps up wealth unjustly, becomes a parasite draining the life of others without equitable return. He will accumulate wealth, but his own nature will surely deteriorate, and not only his own nature but the tone of the country in which he can so act and yet be approved of his fellow-men. The antagonism here, the self-defence to which the struggle for existence gives rise, will be the antagonism of those who are ground down; and in the bitter war of labor against capital, of poverty against vast wealth, the country and all in it suffer.

Have we not to some extent lost sight of this truth in the present day? In the rapid advance of civilization during the last hundred years, have not the whirl of machinery, the spread of commerce all over the globe, the opportunity of making colossal fortunes, the herding together of men in our great cities, and the absence of personal intercourse between those interested in any great enterprise, led men to neglect the human sympathy which ought to exist between employer and employed? Do we realize that even from the point of view of an enlightened selfishness it is to the interest of each to advance the welfare of all? Is not the habit growing upon us of treating men as money-making machines to be obtained at the least possible cost, forgetting that antagonism is always created when one living being takes from another without rendering back in due proportion, whether in kind, in gratitude, or in sympathy? Do not strikes and labor combinations, and our fierce social hatreds, warn us that in political economy, as in the science of life, the law of mutual help must work side by side with that of personal gain?

The question is no doubt a very difficult one, the interests involved are so many and the results produced so complicated, that even those who seek honestly and have ample experience, are often inclined in despair to give up the problem as hopeless. But at least it is something gained if we can establish from the laws of nature that to grind down those who work for us to the bare limits of subsistence, and to try to make the balance even by charity, is only to create antagonism on the one hand, and parasites on the other ; while the masses will also do well to remember that, even in plant-life, the store-accumulating perennials are not without their value, as affording shelter and protection against rivals and inclement seasons.

Meanwhile the spirit of "each one for himself," which is being woven into the very fibre of the present generation, is doing infinite harm for the love of self, already made strong enough by the battle for self-preservation, is increased until the narrow circle of one small life is all that each considers. Then it is that a man, step by step, loses sight of all his true relations to his fellow-beings, and either deteriorates into a mere lover of pleasure or gain, or drifts into crime. Many of the worst, because most cold-blooded and heartless, crimes of our day can be traced to this utter disregard of anything but personal gratification or gain. For when a man's own desires become the whole end and aim of his life, he does not hesitate to sacrifice others to them. Therefore, whether it is money, or position, or sensual gratification he seeks, the passion becomes stronger than all other considerations, and he is led on to self-indulgence, deceit, and fraud, or even, when detection becomes imminent, to carefully planned murder to remove any difficulty from his path.

Such deliberate crimes, of which any one can recall instances from our daily papers, do not fortunately often occur, but they are startling proofs how necessary it is that natures which cannot be influenced by the higher law, which we shall discuss in the next chapter, should at least recognize that throughout all life a being wholly selfish is at war with the entire world, and must in some way or another suffer in the end. No doubt many will exclaim at this point that they themselves know selfish lives which, while sacrificing others, seem to escape all retribution or remorse ; and this is no doubt true, for in many cases the "postponement" is long. But if the law be true, this is only an additional argument in favor of a point to be urged by and by (p. 10), that *in the end* they will have "to pay the whole debt."

Happily, however, this low motive of "self" is not the foundation of morality, for were it so, then, indeed, existence would be the cruel heartless struggle that some would even now have us believe it to be, in which each would coldly calculate how much service to others would secure most benefit in return ; and in which all the higher emotions of love, gratitude, self-devotion, and sympathy would have no place, since to rise upon the downfall of others would be the highest ambition of all.

But this is not so. We have as yet touched on only one, and that the lower side of the question. We have been considering the arguments which might influence such men as look upon "right and wrong merely as matters of expediency as to what will best serve their own ends," and have shown that even on these grounds they must be honest, trustworthy, just, and to a certain extent regardful of others, lest, having the laws of life against them, they should be crushed under the more vigorous and healthy natures.

For, as we shall see in the next chapter, the care of our "other-selves" has, from the very start of life, been educating living beings in the higher altruistic qualities, without which even the varied beauty of the plant world could never have been developed; which in animal life, have gradually opened out the faculties more and more to unselfishness and self-devotion; and which, in the ascending tide of human life, have become to us a faint foreshadowing of Infinite Love, Sympathy, and Fatherly Care.

It is the absence of this higher side which, above all things, makes bad men or women, for without it they are blind to the whole end and object of our being, which consists in finding our happiness in others, and all in God. And this can be founded as firmly on science as on religion (as, indeed, must be the case with all that is true), for upon it rests the existence and continuance of all races and species of beings from the beginning of time. Without self-preservation and the protection of the individual, life could not exist; without self-sacrifice and preservation of the young, life could not continue; and thus the actual existence of a world of living beings has its foundation in the service of others. It is when we turn from the depressing atmosphere of self to this higher instinct which seeks the good of all, that we mount from earth to heaven.

CHAPTER VI.

"Duty! Wondrous thought, that workest neither by fond insinuation, flattery, nor by any threat, but merely by holding up thy naked law to the soul, and so extorting for thyself always reverence, if not always obedience; before whom all appetites are dumb, however secretly they rebel; whence thine original?"—KANT.

WE have seen in our last chapter that though men who are utterly selfish may, and must from self-interest, think of what is good for others, yet this calculating altruism can never deserve the name or assume the character of morality. We feel at once that the man who refrains from cheating his neighbor merely because "honesty is the best policy" is not at heart an honest man; while he who performs a generous act, reckoning all the while what he will gain in return, is not unselfish.

To be really moral, needs a higher motive than this, a sense of duty, an enthusiasm for that which is good and noble. Can the laws of nature then have developed in us this earnest sense of duty, which a true man *dares* not disobey, even though it curb his strongest passions and desires? Not only is it possible, but the whole scheme of the continuity of the universe leads us to believe that this, too, is the outcome of evolution, or the unfolding by natural law of the will of the Creator, showing that the foundations of morality were not laid merely in man, "upon whom the ends of the world have come," but in the very beginnings of life.

Even among plants it has been the necessity of providing for a future generation which has developed endless devices in the flower for the fertilization and protection of its seeds; while in the insect the mother devotes her whole energies and risks her life to secure food and safety for the offspring which she will never see, taught by an instinct developed in the struggle for existence by the survival of those forms which best fulfilled these functions.

Is it wonderful then that, after long ages of inheritance, this instinct should become so strong as to impel even neuter bees and ants to perform a mother's duties to those who are placed under their care? And this work for others has no root in *self*, in the strict sense, except in so far as the creature exercising it satisfies an instinct. The butterfly or the sphex gains nothing herself in providing laboriously for her young; and though, when we come to communities, the young bees and ants do in time become useful in the hive, yet it is clearly no calculation of this kind which makes the workers nurse and tend them, but an inner necessity stronger often than the preservation of their own life. So too in the higher animals this instinct, developed in both father and mother and inherited by the ancestors of man, acted but feebly at first in the savage, who cared only for his own family or tribe, but became strengthened, enlightened, and purified by ever-developing intellect, by the conscious love and care of parents, by the memory of sympathy given and received, and by the survival of those communities, races, and nations in which fidelity, justice, obedience, and similar virtues knit the members strongly together.[1]

And thus it becomes evident that the stern law of natural selection, though it often enables the strong, the selfish, the hard, and the exacting man to survive, just as it has produced the grasping parasite, the prickly thorn, and the bloodthirsty wolf; has also developed in far greater proportion the loving, the tender, the just, and the disinterested, as it has the mutual attraction of insects and flowers, the industrious law-abiding bee, and—aided by man, himself a product of the same laws—has developed out of the very wolf-tribe itself the faithful, devoted, and affectionate dog.

The moral nature then within us is no sordid balancing of debtor and

[1] See *Descent of Man*, chap. v.

creditor account between ourselves and our neighbor, but the true voice of the Creator, which has spoken from all time; saying first, "Parents love your children," and then to members of a social community, "Thou shalt love thy neighbor as thyself." And while this command expressed in natural law has played a large part in the production of all forms of healthy life, so also by virtue of it have communities existed. For mere self-interest, pursued without regard to the rights of others must, as we have seen, create antagonisms, and in the end would ruin any nation or country which acted upon that principle alone, or even one in which it outweighed the principle of mutual help.

Nor is this merely a feeling or emotion gratifying to the sentimentalist, for then it would be useless in the struggle for existence. It is really the recognition of universal life as one great whole, of which we each as individuals form part, so that we cannot injure ourselves or our neighbor without, in so far, injuring all life, while the self-denial or suffering we may incur to benefit others enriches all, so long as it does not actually injure or debase our own nature.

And now we are prepared to answer the question how a man may hold his own in the struggle for existence and yet sacrifice much for the good of others; and this not with a view to ultimate gain to himself, but because duty prompts and his higher nature responds gladly. Surely by seeking to develop his own life in such a manner as to produce the greatest good for every living being.

The self-regarding virtues, such as self-reliance, courage, prudence, industry, perseverance, and temperance in all things, are essential to him; for we have seen that each individual must strive to live and flourish, and make the most of any opportunity to improve his own condition, and that, in the struggle for existence, no effort can be spared. Yet we feel instinctively that these virtues are higher when we exercise them for the good of others as well as for ourselves, and temper them with the altruistic virtues of honesty, fidelity, justice, sympathy, mercy, and benevolence. We respect the resolute man who toils day and night, who gives up his pleasure for work, lives by rule, and sternly represses all excesses lest they should hinder him in attaining success, and when he has achieved it, we feel he has deserved it. But we estimate far more highly the man who exercises the same self-denial and perseverance for the sake of mother or sisters dependent on him; whose prolonged study has for its object the discovery of some truth by which the sufferings of his fellow-men may be mitigated and their condition improved; or who aims at being the master of some great organization not chiefly for position and wealth, but because it gives him power to study great social and commercial problems, and to put on a surer footing the relation of man to man, class to class, and nation to nation. And the reason we value such a man more highly is because he aspires beyond the narrow duty of self-preservation to the world-wide purpose of good to all.

Though this purpose has been gradually worked out through all life, yet we cannot call the lower animals moral or immoral, for they "follow the law but know not the doctrine." Held fast, for the most part, in the grip of blind instinct, they are examples of mechanical duty; while, except in the higher forms, they are probably never conscious of more than passing sensations. But man, emerging into self-consciousness, remembering and reflecting on past actions, and resolving upon future conduct, has to choose deliberately between conflicting emotions and interests, and by this conscious choice has a terrible power for good or ill. Thus impulse and reason, the love of self and the love of others, the gratification of appetite and sense, and the restraining influence of higher faculties, contend within him and make his inner life a struggle. As he can rise infinitely above animals, when by reason and judgment he acts in accordance with the higher laws of his being, so he sinks deplorably below them when yielding to gross and selfish desires, he chooses the ways of vice and degradation.

Which road he will take will depend chiefly on two things—on the cultivation of his intellect, by which he discerns the sequence of cause, effect, and the consequences of his own actions and those of others,—and still more upon his moral nature, his sense of oneness with mankind, and with the whole of creation, which keeps him in touch with his fellow-men, with the universe, and with the Unseen Power which is breathing within him the breath of life. The man who has no sympathy, whose inordinate desires are strong, and his social instincts weak, is essentially a bad man; yet another may also act with bad results because, though his sympathy is strong, it is guided by a weak intellect.

The cultivation of the intellect becomes, therefore, a supreme duty, while the development of love and sympathy is equally imperative. By the cultivation of the first we recall vividly the memory of past actions, and reflect upon the consequences to which they have led; by the exercise of the second we render the memory of bad and selfish actions intolerable, and desire intensely to make reparation as far as lies in our power. And this is *conscience*, the voice of the law of God within us, which speaks far more strongly than the outer voice of the praise and blame of others. For these only read our motives imperfectly, while we judge ourselves with the knowledge of the thoughts hidden within us; and this judgment becomes keener the higher our intellectual sensibility, and the deeper our sympathy with our fellow creatures.

Nor are we left without guidance even from the outer world, for we have the history of past ages spread out before us. Far from being restricted to observations upon the life below us, we can study the science of human life by the light of natural law, and take example from those higher types which, from time to time, have risen above the level tide of man, and by superior intellect and more abundant sympathy have approached more nearly to the Source of both.

"Lives of great men all remind us,
We may make our lives sublime."

And in all countries and climes, from Buddha to Christ, and from the early Christian heroes to those of our own day, we shall find that the noblest natures, whether searching after truth like Newton, withstanding wrong and oppression like Abraham Lincoln, or going to almost certain death like Gordon, in the hope of being of some use to his "poor, ignorant, black children," have all followed the law taught alike by science and religion, that he who devotes his life to duty is fulfilling the truest purpose of existence.

It is when we study the lives of such men as these, that we notice how closely morality is united to all true religion in whatever creed it is expressed ; how in working for all we are working with God ; and it is also then that the problem of evil existing in the world presses upon us most heavily. We have seen that this problem cannot be solved with our present imperfect knowledge. Why suffering and degradation should accompany the evolution of all good and happy life must at present remain a mystery to us.

The study of the struggle for existence does to some extent lift the heavy cloud hanging over us, by showing that all low thoughts and actions relate to the narrow life of self. They are the by-products of the effort of every being to hold its own in this life ; and we have seen how such effort lies at the root of all progress, and of the very existence of varied and vigorous beings. But we have also seen that from the very beginning the love of our "other-selves" has tempered this instinct of self-preservation, and since those, who in working out their own life work for the good of all, have been shown to be the fittest to survive, it follows that, in an infinite and eternal scheme, this higher mode of work must, in the long run, prevail, and suffering and evil must be gradually eliminated. Not, however, necessarily in this life, where our bodily restrictions are so great that the individual is always to a certain extent at war with the whole, and where the time is so short. If the full bearing of evolution is to be worked out, it must be in a scheme which embraces the entire universe.

This brings us face to face with the question of immortality which is so profound and so difficult to deal with from the point of view of science that the boldest might hesitate at attempting it. My only excuse for doing so is, that it is intimately connected with all higher morality, and that, therefore, it is a serious duty in those who believe they see a vista in science through things temporal to things eternal to state their convictions.

It appears to me that our intellect, our moral nature, and the conclusions of science, even apart from religious belief, all point to a continuation of individual existence beyond the few short years we pass in this world.

Our intellect carries us back through all phenomena to a first cause which, because in Him all things exist, cannot be other than omnipotent. It is impossible, and a contradiction in thought, to imagine that such a Power could be the author of an imperfect or unjust scheme, such as this world must be if those who, through inheritance or evil surroundings, pass lives of suffering, disease, misery, and degradation here, should live only their little span and pass away into nothing. A perfect scheme must be perfect not only in general results but in every minute detail, and though the pain and suffering around us are undeniable, and our limited experience makes it difficult for us to understand how they can have been necessary, yet as antagonism is impossible in an an Omnipotent and Sole-existent Power (see p. 14), the only really logical conclusion is that they must, in some way unseen to us, be actually good not only for the universe as a whole, but for each individual.

So far is the argument of intellect and logic ; our moral nature speaks next. To a thoughtful mind it is not the longing for the prolongation of our own existence which makes a future life an imperative necessity, but a jealousy for the honor of the eternal Being of whom we form part—a conviction that "man cannot be more just than his Maker." Though selfishness and callousness to the welfare of others may linger in the lower strata of our nature, that which relates only to our individual self ; yet our higher life, that which touches the universe, is strong in the sense of justice, sympathy, and mercy ; and these qualities in ourselves, which we know can come only from the Source of all life, are an absolute proof that the Omnipotent Power, by whose laws we exist, must possess these qualities among His many inscrutable attributes ; and that, since a just man would, if he could, redeem those who, in the struggle for life, have been too heavily weighted to rise, there must be a compensatory power in the universe which will, in the end, work out their existence to a just conclusion.

For this consummation continued existence is necessary beyond the present unevenly balanced life, and the strongest arguments for it lie in these conclusions of our intellect and moral nature. Yet science too lends her aid, if only we will keep our minds fixed upon the truth that throughout all phenomena it is the underlying invisible energy which is eternal, the form which is temporary.

In the inorganic world we trace physical energy in various forms producing all phenomena, and in the organic world we find this same energy utilized in every living being in the building up of cells and tissue, and in the physical action of nerve and muscle. Thus, physical energy may be said to provide the necessary motive-power for living beings, in the same sense that plants provide the initial nourishment for the whole animal world. Yet this does not prove that animals have no higher existence than plants, nor that living beings are mere manifestation of physical energy. On the contrary, Professor Stokes, who of all living men is perhaps most competent to estimate what physical energy can accomplish, says : "admitting to the full as highly probable, though not completely demonstrated, the applicability to living beings of the laws which have been ascertained with reference to dead matter, I feel constrained at the same time to admit the existence of a mysterious *something* lying beyond, a something *sui generis* which I regard, not as balancing and suspending the ordinary physical laws, but working with them and through them to the attainment of a desired end."[1]

This desired end, as far as we can see, is individualization transmitted by inheritance, and if we once arrive at the conclusion that science (as well as the common belief of mankind) recognizes something in living beings apart from, and not convertible into, physical energy, it matters very little whether, in the past ages of evolution, these two factors branched off from a common source, as plants and animals branched off from single living cells, or whether life has always been a separate and higher emanation from the First Cause. In either case this last has been the guiding power in all living beings, the *cause* and not the consequence of organization; and organic growth, reproduction, sensation, perception, self-consciousness, and volition, although always accompanied by molecular changes, can be conceived only as manifestations of life, just as heat, electricity, and chemical affinity are manifestations of energy. The mere dissolution of the bodily frame can no more destroy one than it does the other, while, however, there is this great differance between them, that whereas we know that the energy passes back in various forms to the sum-total which remains constant in the universe, the guiding control which we call "life," with all those wondrous powers which belong to it as the result of long ages of evolution, cannot, so far as our experience goes, be transformed, but passes out of the visible universe—we know not whither.

It is true that those who do not believe in continued existence after physical death argue that we have no knowledge of conscious life outside of that which we term matter. It is possible they may be right, although, since matter, energy, and life are all alike mysteries to us, except through their manifestations, we cannot, I think, dogmatize far in this direction. But even if we allow their position, when can we declare that life would be "outside matter"?

Our only explanation of light reaching us from distant stars is founded upon undulations of a supposed ether filling all space, and permeating all transparent objects upon our earth, and yet absolutely invisible, imponderable, and intangible to us, so that its existence has not as yet been

[1] President's Address, British Association, Exeter, 1869. Professor Oliver Lodge has expressed the same conclusion briefly and clearly in his address this year to the Physical Section of the British Association: "The relation of life to energy is not understood. Life is not energy, and the death of an animal affects the amount of energy no whit; yet a live animal exerts control over energy which a dead man cannot."—Report in *Nature*, 20th August, 1891.

verified by any experiment. If we need a hypothetical material pervading all the visible universe to account for the transference of physical energy which, we know, takes place across space to and from our solar system, why make a difficulty as to the possible passage of life into the far beyond?

This is, however, only a suggestion in answer to an often-made objection, and carries us beyond our point, which is that life, being the cause and not the consequence of organization,[1] does not depend upon it for a continued existence; and that, since all those qualities and idiosyncrasies, which constitute our inner self are manifestations of life, they cannot be affected in any way, beyond mere outward expression, by the dissolution of the bodily frame. Long before physiological science had reached its present stage, Bishop Butler, in his *Analogy*, emphasized this point; and one of our greatest living biologists, though himself not hopeful of the future, pointed out the argument to me, and acknowledged that it had never been refuted, and so far as he saw never could be.

If we are constrained, then, to look upon life as an ever active force working from the lowest to the highest form and in itself indestructible, are all living existences to continue? This is another point upon which it is impossible for us to form a definite conclusion, because even in this life individuality exists in very various degrees. The individuality of the plant is infinitely inferior in grade to the individuality of the animal, just as the life of the insect is not comparable to the self-conscious life of man; but as Bishop Butler again pointed out, the continuation of all life is the only logical conclusion, and the universe has surely room and work for all grades of the living principle.

Startling as this may appear at first sight it becomes less so when we reflect that suffering and struggle have existed from the beginning of life, so that in all sentient beings annihilation would leave an unjust balance. The same argument applies here which was used with regard to our appreciation of the intelligence of animals. Everywhere an increase of knowledge leads us to see continuous gradation throughout all life, and to acknowledge that we are only beginning faintly to comprehend the possibilities of nature.

But while this consideration must lead us to a much deeper sense of our duty towards animals than is commonly felt, it does not seriously affect our estimate of that individual responsibility in the case of human beings, which concerns us in dealing with the question of morality. It is the continuity of the life of each individual man, with its qualities and idiosyncrasies, which becomes of such vast importance if the arguments urged above are sound. For, as in this life, the vast superiority of man in his power of abstract thought, spiritual apprehension, and moral

[1]The German philosopher Wundt says: "The psychical life is not the product of the bodily organism, but the bodily organism is rather a psychical creation in all that, by its purposive power of self-regulation, gives it precedence over inorganic bodies."—Quoted by Dr. Mivart, *Truth*. p. 426.

resolve, makes him the arbiter of his own success or failure, so his power of anticipation of a future life gives a new and overwhelming impetus to his moral nature. On the side of self-preservation alone it warns him that the consequences of his actions are far-reaching, and that the penalty which he seem to escape here is "only a postponement. First or last he must pay the whole debt."

And here we have the answer to those who urge that an enlightened selfishness may enable a man to further his own ambition and indulge his vices at the expense of others, and yet escape unpleasant consequences himself and enjoy life to the end. He may, indeed, do this when a less astute egotist would bring a speedy retribution on his head ; but none the less he is storing up in his nature elements antagonistic to the good of all, and as such elements are least fitted to survive in an ever-progressing evolution, sooner or later the consequences must react upon him—the narrow self at war with higher life must be crushed out.

On the other hand, what an impetus is here given towards a higher and nobler life for ourselves, and self-sacrifice for others ! If we are willing to labor and spend ourselves to mitigate the sufferings and better the condition of our fellow-beings for a few short years, how much more then, if we feel that the wretched state of their existence is dragging down the life which should be progressing, and learning all that can be learned here before passing into a wider sphere.

For in this as in all else we cannot escape from continuity. That which the individual life has gained or lost in the struggle here must characterize it in its onward path till a wider experience and emulation has developed the nobler and stifled the narrower and lower instincts.

Using the faculties he inherits, and working out his inner self by the experience he derives from the conditions under which he lives, man is moulded on this earth for good or for evil. It is no doubt depressing to contemplate how many leave it degraded by lives of self-indulgence or grinding misery. Yet none, not even the grossest sensualist, or the most hardened criminal, was ever without some spark of higher life, some love for a little child, some generous feeling towards those who have not cast him out in his degradation.

And when we carry on the life-principle into the boundless universe, and remember that the slightest spark of good must survive since it is of value to all, while, as we have seen, evil must be eliminated as injurious to all, then the pessimism induced by contemplating the ills of this life, is replaced by a patient optimism. For hope goes on before us, justifying the highest promises of religion in all ages, and we can dimly foresee how, through the action of ever-widening sympathy, the narrow boundary of self will break down more and more till our own individuality will survive only to be merged by sympathy in that of others. When that time comes, as surely it must, we shall realize at last that we are indeed but individual fractions of One Universal Life.

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Beacon Lights of Science

THE

ROMANCE OF ASTRONOMY

BY

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Cambridge, England

WITH AN APPENDIX

BY RICHARD A. PROCTOR

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PREFACE.

The greater part of the following papers was originally written for delivery in the form of popular lectures. They were then published in a University magazine, the *Light Blue ;* and having met with considerable success in both these ways, they have now, at the suggestion of several friends, scientific and non-scientific, been partially rewritten and enlarged into their present form.

I have endeavored, however, to keep their original object unaltered, and to write nothing which would not be at once interesting and intelligible to non-scientific readers. There is no lack of systematic, and yet easy, works on Astronomy, such as those of Sir John Herschel, M. Arago, and Mr. Norman Lockyer ; and I have, therefore, made it my object not so much to instruct as to entertain, and possibly in some cases to inspire a taste which might lead to the further prosecution of a most fascinating study. This must be my apology for passing over entirely many important parts of the subject, and simply selecting a few points here and there which seem to afford scope for striking or amusing amplification.

Since the following sheets have passed through the press, I have learned that Professor Adams and others have thrown grave doubts upon the accuracy of the calculations upon which Professor Hansen's theory of eccentric gravitation at the moon was founded. Should this theory fall to the ground, the argument for the habitability of our satellite which was founded upon it, and which I have explained at page 11, must go with it. But it will remain as a striking and interesting episode in the history of scientific speculation.

In the note to page 9 the fact of the moon's always turning the same face toward us is spoken of as a question of Rigid Dynamics. But it is possible that it may rather depend upon the earth's action on the moon while in a viscous state.

I have to thank two very distinguished members of my own college, Sir William Thomson and Professor Tait, for kind suggestions and advice.

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Beacon Lights of Science

THE ROMANCE OF ASTRONOMY

The Romance of Astronomy strikes one at first as sounding something very like a contradiction in terms. We might naturally be inclined to think that there is about as much of romance in astronomy as there is of poetic fire in Martin Tupper, or of charity in a Saturday Reviewer. Any one listening to the conversation of two astronomers, and hearing them descanting enthusiastically about perigees, apogees, and syzygies, right ascensions and declinations, precession of the equinoxes, and the longitude of the moon's ascending node; or any one opening at random the pages of a work on the science, and finding an incomprehensible mass of calculations, formulæ extending over twenty lines and using up all the letters of two or three alphabets, and diagrams like nothing in the earth beneath, or in the waters under the earth, and only bearing a very faint resemblance to things in heaven above; any one, we repeat, on getting such an introduction to the subject, would be very much tempted to think that romance and astronomy were altogether incompatible. Science is said by rhetoricians to be the logical opposite of poetry, and whence then can come any element of romance into the sternest and loftiest of the sciences?

But if we consider not so much the study of the science itself, in its profound and recondite details, as the results to which it attains, the magnitude and importance of the subjects it treats of, and the beauty and grandeur of the phenomena it investigates, we shall have to acknowledge that somewhere or other in the ponderous tomes of astronomical science there must lie entombed rich stories of novel and unwonted interest. The science which fathoms the infinite and reckons up the eternal, which pierces the abysses of space, grasps the orb which we see now by the light that left it eighty thousand years ago, measures its distance, and traces its movements—the science which accomplishes such marvels as these, and the history of the great men who achieved these noblest triumphs of human intellect—must surely furnish many themes and contain many episodes of a character as wonderful and as truly romantic as we can find within the airy realms of fiction or of poetry. And besides the grandeur of the phenomena of astronomy and the romance which gathers round its history in all ages and casts a brilliant gleam here and there upon its sober annals, there often flashes even across the pages of the driest and most mathematical parts of the subject a glimpse of strange and unexpected interest; and a fact here and a figure there will start the mind in a train of fresh and novel speculation, and set the fancy to luxuriate in new and untrodden realms. Many of these points moreover to which we allude, though very interesting and wonderful in themselves, are yet of comparatively little importance from an astronomical point of view ; their interest centres in themselves, and the results to which they lead must be regarded as rather curious than valuable ; and hence they are but little to be met with in books, or if touched upon at all, are soon abandoned with the remark that it is time to quit such regions of endless and unavailing speculation. Now some of these speculations we purpose following out a little to their legitimate conclusions, trusting that from the above reason they may prove new to many of our readers. And in the other points which we take up—for we must not confine ourselves to so limited a portion of the romance of astronomy as this alone—we shall seek to select those which are likely to prove at once the most striking and the least familiar to non-scientific readers.

THE PLANETS.

We turn naturally first to our sister planets. They are in all respects analogous to our own globe ; they hold the same position in the great system of the universe that we do, and in them—if in any of the orbs of heaven at all—we might expect to find the face of nature presenting the same appearance, and the course of nature the same phenomena, that they do to us. But not such, do we find to be the case. Some of them indeed will resemble us pretty closely in one thing and some in another, but in every one the points of contrast will be much more numerous and striking than those of similarity.

In looking over a table of the elements of the planets, one of the points which most attract our attention is the very great differences in size which they present ; and as this circumstance is the cause of some of their most striking physical peculiarities, we may commence with it our examination of them. It affords, too, a remarkable illustration of the statement we have made, that a fact of apparently little importance in itself often leads indirectly to very unexpected and startling consequences. The magnitude of a planet is a point we should never expect to find in any way necessarily connected with the nature of the beings who inhabit it and the general character of life at its surface, and yet we shall find it intimately related to these matters, and that to the production of very singular consequences indeed. Take for instance the case of one of the minor planets—Ceres, or Pallas, or Vesta. Astronomers tell us that the diameter of the earth is 7912 miles, and that of Ceres 160 miles ; and the words may very easily pass in at the one ear and out at the other, without leaving any impression behind ; or if we pause for a moment to think over them, it will likely only occur to us what a compact little world Ceres must be, how easy it must be to get from one place to another in it, and how delightful to be able to sail round the world, pay a visit to one's friends at the Antipodes, and get settled at home again—all within the short space of a week. But if we look at the subject a little more closely, we shall find that it involves far more extraordinary consequences than these. We know that by the law of gravitation, the force with which one body attracts another varies directly as its mass, and inversely as the square of its distance; and also that a sphere attracts any external object as if its own mass were all collected at its centre. Now the diameter of the earth being fifty times as great as that of Ceres, it is altogether 125,000 times as large; but this disproportion being partially counteracted by the greater distance of its surface from the centre, it follows that on the whole the force of gravity here is fifty times greater than at Ceres—or, in other words, any object here is fifty times as heavy as it would be there. Now let us look for a moment at what is implied in this. The first and most obvious consequence is, that a man will be able to lift fifty times as great a weight there as here. A ton would be an easy load, boys would play at ring-taw with huge round boulders instead of marbles, and a rattle intended for a stout baby might be made as massive as a moderate-sized cannon-ball. If the tower of Siloam had fallen there instead of here, the men, instead of being crushed by its weight, would have lifted themselves and it up with the greatest ease, and felt nothing the worse for the accident. But there are more singular consequences yet. We know that if a body be once set in motion, it would continue moving to all eternity, if not brought to rest by some external force. Thus when a man leaps up into the air, he would continue ascending forever, were it not for the attraction of the earth, which very speedily brings him down again. But at Ceres, this force is so small that it will be much longer before it takes effect, and a man might consequently leap to an enormous height before the attraction would check his ascent. Jumping over a housetop would be a very trifling exploit, while a good leaper would think nothing of clearing, with a short run, the new tower of St. John's Chapel, or the Great Pyramid itself. Staircases might be abolished, for even a stout old lady could easily jump in at a three-story window. The range of projectiles would be increased in proportion. Ensign Humphry, with a good telescope, would put a ball into the bull's-eye from a distance of twenty miles. An economical war-minister could no longer build on the security afforded by "the streak of silver sea," for Great Britain might be swept with artillery from the Land's End to John O'Groat's House, by batteries erected far inland on the continent.

Nor have we exhausted the wonders of Ceres yet. When Swift made Gulliver describe his adventures among the Brobdingnagians, he probably had no idea that they were even farther removed from reality than the other creations of his fancy—that they were not only myths, but absolute impossibilities. A giant here would be crushed by his own weight. A very easy calculation will show this. Suppose a man twelve feet high, and stout in proportion. He will be twice as long, twice as broad, and twice as thick as an ordinary mortal, and thus eight times as heavy. Now if we take a cross section of his leg, the cut surface will be twice as broad and twice as wide as usual, and thus four times as large altogether. We shall thus have eight times the ordinary weight to be supported by only four times the ordinary surface; and hence the stress on the bone will be twice as intense as usual. In the same way, in a man three times the ordinary height, the stress would be three times as great, and so on. Such a stress might perhaps be borne, but when we got the length of a giant sixty feet high, the stress would be ten times as great, and that the bone certainly could not bear. It would either be crushed outright if the giant attempted to stand erect, or else his legs would totter, his knees would bend, and his mighty body come thundering down to the ground. Once down, it would be utterly impossible for him to get up. A sitting posture he might perhaps compass ; but if he were a very big giant indeed, that too would be out of the question—and he could do nothing but lie along on the ground. But transport him to our queer little friend Ceres. and he is all right at once. In a moment he becomes fifty times lighter than he was, he leaps to his feet with ease, and rears his huge head sixty feet into the air, his legs recover their strength, his aching bones grow well, and he may proceed, if he please, to astonish the acrobatic natives of the planet by gymnastic exploits far surpassing even their own.

Indeed, all the wonderful feats we have seen that an ordinary man would be capable of at the surface of Ceres, must be multiplied fifty-fold when we take into account the superior possible size of the inhabitants of that planet. Muscular exertion there goes fifty times as far as it does here ; and as these gigantic beings will be able to put forth at least fifty times as much of it, the exploits they will be capable of achieving must be no less than 2,500 times as great as anything that could be done here. Upon this enlarged field of speculation we can scarcely venture to enter. The wildest flights of fancy, and the most exaggerated visions of fairyland, will be more than realized. Like Milton's angels, they could tear up the hills by their bases, and hurl them at their foes. Stronger than the vanquished Titans of old, fetters of iron would be to them as threads of gossamer ; and mountains piled on the top of mountains would not suffice to crush or imprison them with their load. Like the genii of the Arabian Nights, they could spring at a bound from the earth to the clouds, or clear half a dozen miles at a single leap. The seven-league boots would be no longer a fable. Puck said he would put a girdle round the earth in forty minutes ; but one of these giants of Ceres would stride round his planet in less than half the time. Of course all the other denizens of the asteroid will have their size and strength increased in the same proportion. The racehorse will rear his crest two hundred feet into the air, and gallop five thousand miles an hour. The giraffe on the plain will lift his stately head, and browse on the trees that crown the mountain-top. The ponderous elephant will cover three acres of ground, and surpass in strength the most powerful steam-engine. The lion's roar will be more dreadful than the thunder-peal, and his resistless spring more terrible than the lightning's flash. Snakes two hundred feet in circumference and a thousand in length, will roll their huge coils through the forests ; while the sea will boil and foam with the gambols of its mighty inmates, and the gigantic carcass of Leviathan extend for a mile along the deep.

If we reverse the circumstances, and go to a world larger than our own instead of smaller, the case will of course be exactly the opposite. If we ourselves were transported to the sun, we should feel as much like fish out of water as the colossal inhabitants of Ceres would do here ; and in fact it will be readily seen that if the sun were inhabited by beings constituted like ourselves, its population could consist only of dwarfs two or three inches in height. Very singular it surely is that the larger the world, the smaller its denizens must be, that the inhabitants of the earth should be men, those of the sun dwarfs, and those of the tiny asteroid giants.

We must remind our readers—what they might well be excused for forgetting—that we are not romancing about what might be the case in some absurd and impossible circumstances, and if the laws of nature were to undergo some extraordinary and unheard-of change, but that we are speaking in all truth and soberness, and that what we have stated is absolute and demonstrable fact.* If any man were transported at this moment to the planet Ceres, he would be able to do everything we have mentioned; and the actual inhabitants of that planet, if constituted like ourselves, must be able to do the same. Whether, if they exist at all, they are beings like ourselves or not, of course we cannot tell; their frames may be feebler and their powers more limited than our own, and life at the asteroids may be after all not so very different from life on the earth itself.

And now to consider a few other points connected with the planets—those namely which arise from their various positions relatively to the sun, and from the character and velocity of their movements. The general celestial phenomena, and the periodical changes connected with them, must of course be the same at all the planets. They have the same alternation of day and night, of summer and winter, that we have. For them, as for us, the sun has been set to rule the day, and moons and stars to rule the night. But though their times and seasons, their days and years, are exactly analogous to our own, yet the differences in their positions and movements will produce corresponding differences of a very marked kind in the lengths of those periods and in the vicissitudes of climate occasioned by them. The most important of these differences are caused of course by the very various distances from the sun at which the planets are situated. Mercury is three times nearer it than we are, and Neptune thirty times farther away. It follows from this that at Mercury the sun will appear nine times as large as it does to us—the intensity of its light and heat being of course increased in the same proportion; while at Neptune all its influences will be nine hundred times feebler than they are here. Hence at the former planet the average heat must be greater than that of boiling water: and if at its creation it contained any seas or rivers like our own, they must have been long ago dissipated in vapor by the sun's overpowering beams. At Neptune, on the other hand, that luminary will appear no larger than one of the planets does to us. How cold and drear an abode it must therefore be!—its brightest noon-day more dusky than our winter twilight, and its hottest midsummer far colder than our frozen poles.

Another consequence of the varying distances of the planets is a great diversity in the length of their years, some of them being as short as three of our months, while one extends over no less than a hundred and sixty years. How long and dreary the circle of the seasons must be there!—forty years of spring, forty of summer, forty of autumn, and forty of winter. The contrast

* See Herschel's Astronomy, end of chap. viii., where some of the above ideas are hinted at. Our mathematical readers will see that there is not the slightest exaggeration in the extent to which we have carried them.

between the seasons will be in some of the planets greater, and in some much less than our own; at Jupiter especially there will be no perceptible change of seasons at all, and day and night will everywhere last for twelve hours each, just as at our equator. The orbit of Mercury presents a very marked eccentricity; in other words, the planet is much nearer the sun at one period of its revolution than at another; so much so that that luminary will appear twice as large, twice as bright, and twice as hot, when Mercury is in perihelion as when in aphelion; a circumstance which cannot fail to be productive of very serious effects to its inhabitants. Even at our own earth, whose orbit is so much more nearly circular, the same cause produces a quite perceptible effect. The earth is nearest the sun in December, and the consequence of this is that in our northern hemisphere the winter is rendered milder than it would otherwise be, while south of the equator the heat is considerably aggravated. In June the opposite will be the case, and the whole result is evidently to make the northern hemisphere more temperate than the southern. Accordingly we find that the intense heat of the sun is much more complained of in the Australian and South African deserts than in those to the north of the equator. The eccentricity of the earth's orbit is at present diminishing at a small uniform rate*, and the effect of this, in a sufficiently long course of time, would be to decrease these annual variations of temperature. In some of the other planets, however, it is on the increase, and when this fact was first discovered, it excited great interest among astronomers. The increment, though extremely small, appeared to be perfectly regular, and if continued long enough it must infallibly cause such frightful vicissitudes of cold and heat as to destroy any life which might exist at their surfaces. Lagrange, however, succeeded in establishing a beautiful and simple relation between the eccentricities of the planetary orbits, which showed that none of them could ever exceed certain definite limits, and that although they might increase for almost countless ages, a maximum would in time be reached, and a compensating period of diminution would ensue.

Lastly, the rotations of some of the planets on their own axis are performed in much shorter periods than that of the earth. The effect will be to shorten the length of the day, to make the planet bulge out at the equator, and to diminish gravity by reason of centrifugal force. We all know that if a stone be tied to a string and whirled round, it will acquire a tendency to fly off, which will be greater the faster it is whirled. In the same way some of the planets spin round so rapidly as to communicate to any body on their surfaces a very powerful tendency to fly off, which is, however, counterbalanced by the effect of gravity. If Jupiter's rotation were only four times faster than it is, the centrifugal force would be so great that all the inhabitants would be sent flying off through the air—or rather along with it, for it would go too. When the impulse with which they started was lost, they would of course fall back to the ground, but only to be shot off again at once; and in the state of perpetual oscillation, bouncing up and down like an india-rubber ball, they would spend all their lives, unless they took some means of anchoring themselves to the surface of their planet.

* Due to the perturbing influence of the other planets.

The class of phenomena which we have been last considering depend all of them upon the positions and movements of the planets, and are hence common, with various modifications, to the whole of them. But besides these there are connected with all of them special points of individual interest, arising from circumstances peculiar to themselves alone, and over these we must cast a rapid glance before we proceed in our excursion to visit a new set of worlds.

Of the first of the planets, Mercury, we know but little. From the closeness of his proximity to the sun he can never be seen with the naked eye, except occasionally for a few moments close to the horizon, immediately after sunset or before sunrise; and even these hurried glimpses cannot be got except at considerable intervals and under very favorable circumstances.* Hence, though his existence seems to have been known from a very early period, he was comparatively seldom seen before the invention of the telescope. Copernicus lamented upon his death-bed that he had never been able to catch a glimpse of Mercury at all, the mists from the marshes of the Vistula too obstinately fringed the morning and evening horizon round the Observatory of Thorn. A distinguished French astronomer of the same period only saw him twice. The telescope when turned upon him shows us little but a small round disk, which exhibits phases, like the moon, according to its relative positions with regard to the sun and to the earth. Recent observations have revealed enormously lofty mountains upon his surface, eight times as high in proportion to their planet as the Himalayas are to our own globe. The proximity of Mercury to the sun, the eccentricity of his orbit, and the fact that he is unattended by any satellites, rendered the determination of his mass and other elements a matter of much difficulty, and great discrepancies exist between the earlier estimates of them. Fortunately his small size, and the consequent insignificance of the perturbations he produces in the other planets, diminished the importance of having an accurate knowledge of him. Any similar uncertainty about one of the larger planets would have interposed most serious obstacles to the progress of science, and would, for example, have rendered the discovery of Neptune impossible.

It is at present uncertain whether there are any planets within the orbit of Mercury. If there are, their light must be so overpowered by that of the sun, as to render them visible only when he is under eclipse, or when they are passing across his disk, in which case they would appear as small black spots. Astronomers have occasionally fancied that they detected planets under the latter circumstances, but they have never felt certain that what they saw were not merely some of the ordinary spots on the sun. A French astronomer, M. Lescarbault, felt pretty confident on one occasion that he had found a real planet, to which he gave the name of Vulcan; but twenty years have passed away, and the discovery has never been confirmed. It was hoped that at the recent total eclipse Vulcan might have been seen near the edge of the moon's disk when the sun's light was cut off; but if he really

* It is calculated that Mercury, Venus and the Earth will, from a similar reason, never be visible at all from the surface of Uranus.

exists, he lost the glorious chance then offered him of proving the fact, by perversely hiding behind the sun, or between it and the moon.

With Venus we are all familiar. It is the most brilliant of all the planetary or stellar orbs; and the "Star of the Evening, Beautiful Star," has been sung by poets of every age and clime, from Homer to the Christy Minstrels. Like Mercury, and for the same reason, Venus is seldom seen except about sunrise or sunset; but as her elongation from the sun, though limited, is much greater than that of Mercury, she is very frequently visible. Sometimes even, though at rare intervals, she is sufficiently near us to be seen when the sun is above the horizon; and the sight of the little planet, shining softly out in fearless companionship with the dazzling orb of day, is described as singularly striking and beautiful. Varro relates a tradition that Venus shone thus at noonday, a most auspicious portent, upon Æneas' voyage from Troy to Italy. And on the occasion of one of the First Napoleon's triumphal entries into Paris after a successful campaign, Venus joined in the pageant of the procession; exciting the intensest enthusiasm among the populace, who regarded her daylight appearance as a miracle; and flattering even the stern heart of the conqueror with the thought that Heaven itself had sent its fairest orb to grace the brilliance of his triumph. It was long before it was discovered that the morning and the evening star were one and the same planet, and hence we meet with it in the classics under a double name —Lucifer, Son of the Morning, and Hesperus, Star of the Eve. A similar confusion prevailed with regard to Mercury, which as a morning star was styled Apollo, the Lord of Day, and as an evening star Mercury, the Patron of Robbers.

The phases of Venus are readily shown by the telescope, and were detected by Galileo soon after the invention of that instrument. Delighted at his discovery, but unwilling to publish it until verified by fuller observations, he shrouded it in the following line:

Hæc immatura a me jam frustra leguntur,*

which, anagrammatically transposed with a little license, gives

Cynthiæ figuras emulatur mater amorum.†

This ingenious way of embalming a discovery until ripe for publication was a favorite one with the mediæval astronomers, as it enabled them to claim priority, if any one else, by making the same discovery, should take the wind out of their sails.‡ The result of Galileo's first observation upon Saturn was communicated to the scientific world in the form

aaaaabeeegiiiillmmmmmnnoprrstttuvv,

letters which he afterward arranged thus:

Ultimam planetam trigeminam observari,§

Huyghens' discovery of the real nature of the ring was first made known thus:

* These things, yet unripe and not understood, are read by me

† The mother of loves emulates the phases of the moon.

‡ Simon Mayer, a Bavarian astronomer, contested with Galileo the priority of discovery of Jupiter's satellites, but his claim appears to have been not only unfounded but absolutely dishonest.

§ I have perceived the most distant planet to be threefold.

aaaaaaa ccccc d eeeee g h iiiiii llll mm nnnnnnnnn oooo pp q rr s ttttt uuuuu,

which, when he had fully satisfied himself of its truth, he interpreted into

Annulo cingitur tenui plano nusquam cohœrente ad eclipticam inclinato.*

The dazzling and uniform brilliancy of the disk of Venus, which renders it very difficult to get a good telescopic view of it, is supposed to be caused by the reflection of the sun's rays off a dense cloudy stratum; and in fact it seems probable that we never see its surface at all, but only its illuminated atmosphere. In Mars, on the other hand, which is the next planet, we can trace with perfect distinctness the outlines of continents and seas. The bright ruddy light which distinguishes this planet from all the others proceeds from its solid parts, and is caused doubtless by a prevailing reddish tinge in the soil, something the color of our red sandstone, only much brighter. The seas are distinguished by their bluish tinge, while at the north and south poles are large and irregular patches of a brilliant white. These have been conjectured with great probability to be vast tracts of ice and snow; and this idea is confirmed by the fact that they are of variable size, being largest during their winter, and diminishing very perceptibly on the approach of summer.

Leaving this planet of the "Red, White, and Blue," and passing over the asteroids, to which we shall return presently, we come to Jupiter, the largest and most important of all the planets. This great orb is no less than thirteen hundred times as large as our earth, and everything connected with him is on the grandest scale. His years last for ten thousand days, his motion on his axis is so rapid that the heavenly bodies must be seen changing their places every minute, and his nocturnal sky is illuminated by a band of four large and beautiful satellites.† His surface is divided into bright and dark belts parallel to the equator. The former are supposed to represent dense masses of clouds, reflecting the sun's rays more perfectly than the solid body of the planet. Their parallelism to the equator, and their comparatively uniform breadths, are probably to be accounted for by steady atmospheric currents, of a character similar to our trade and return trade winds, but much more violent, in consequence of Jupiter's more rapid rotation on his axis. In fact all the observations upon his atmosphere tend to show that the wind blows at his surface with overwhelming fury, sometimes surpassing a thousand-fold our most terrific hurricanes.

The moons of Jupiter were among the earliest revelations of the telescope. They were discovered by Galileo, who at first supposed them to be stars, and was much puzzled for a few nights by the irregular manner in which Jupiter appeared to move about among them. He had great difficulty in getting the scientific world to acknowledge their existence. Some of the contemporary philosophers thought that they were optical illusions due to an imperfection of

* It is surrounded with a thin plane ring, nowhere adhering to it, and inclined to the ecliptic.

† These satellites have played a very important part in the history of science. Their discovery was hailed as a valuable confirmation of the Copernican theory of the solar system, of which they present a miniature picture. They have proved of great service to the navigator; the time of their eclipses can be calculated with great accuracy, and, when compared with local time, gives a simple method of determining that important and difficult geographical element, the longitude. And some discrepancies between their calculated and observed positions first suggested the great discovery of the finite velocity of light.

the instrument. Many absolutely refused to look through such an unnatural and diabolical engine as the telescope, and of course there was no other way of proving to them that the moons were really there.* One of these sceptics, Libri of Pisa, died during the heat of the controversy; and we find Galileo, in a letter to a friend, charitably hoping that the way to heaven lay past the planet Jupiter, and that Libri might be convinced at last. Another unbeliever, a rather eminent astronomer of the name of Sizzi, delivered an elaborate harangue against Galileo, which is still extant, and in which he argues as follows: "There are seven windows given to animals in the domicile of the head, through which the air is admitted to the tabernacle of the body, to enlighten, to warm, and to nourish it; which windows are the principal parts of the microcosm, or little world—two nostrils, two eyes, two ears, and one mouth. So in the heavens, as in a macrocosm, or great world, there are two favorable stars, Jupiter and Venus; two unpropitious, Mars and Saturn; two luminaries, the Sun and Moon; and Mercury alone, undecided and indifferent. From these, and from many other phenomena of nature, which it were tedious to enumerate, we gather that the number of planets is necessarily seven. Moreover, the satellites are invisible to the naked eye; and therefore can exercise no influence over the earth; and therefore would be useless; and therefore do not exist. Besides, as well the ancient Jews and other nations as modern Europeans, have adopted the division of the week into seven days, and have named them from the seven planets. Now if we increase the number of planets, this whole system falls to the ground."

Absurd as this tirade is, we wonder at it the less when we find the illustrious Huyghens talking in a similar strain after his discovery of the first satellite of Saturn. He says: "The solar system is now complete. It consists of six planets and six moons, and from this equality, and from the fact that they together constitute the perfect number twelve, we infer that no more satellites will be discovered." The philosophers both of the ancient and middle ages had great belief in perfect numbers, but their superstitions have, in the nineteenth century, been thrown completely into the shade by the wild ravings of Comte, the high-priest of Positivism, about primes. Like Sizzi, he had a great partiality to the number seven, because it was a prime, and because it was "composed of two progressions followed by a synthesis, or of one progression between two couples." For these reasons he wished it to be made the basis of our scale of notation. The latter reason we frankly confess our inability to comprehend; the former is intelligible, but singularly inconsequential. Most people would think a prime the worst number possible to found a scale on. His favorite number of all, however, is thirteen, and that for the following reasons: It is a prime; it is the seventh prime; seven is a prime; it is the fifth prime; and five is a prime. Here unfortu-

* It is not quite certain that Jupiter's satellites have not occasionally been seen with the naked eye by persons of very powerful sight. In an early Japanese plate Jupiter is represented with two small stars beside him, which very possibly are meant for two of his moons. At a time when this subject happened to be exciting a little discussion in the scientific world, a German lady declared that she could see one of the satellites. Unfortunately for her probity, it was soon found that she always saw it on the wrong side of the planet—to the right when it should have been to the left, and *vice versâ*. The explanation was easy. She had got hold of some diagrams representing the apparent relative positions of Jupiter and his satellites from day to day, but they were constructed for using with the common astronomical telescope, which is an inverting one.

nately he has to stop; five is the fourth prime, and four, on Comte's principles, is a very poor number indeed. It is a perfect square, and nothing on earth can twist that into a prime. Comte sincerely regrets this little flaw; if only twice two did not make four, thirteen would be an absolutely perfect number. Still it is so near it that it cannot be so very unlucky as it is popularly considered; and we trust none of our readers will ever again think it necessary to count the number of guests at a dinner-table.

Undeterred by the cogent arguments of Sizzi, Galileo, so far from giving up his moons or abandoning his infernal machine, turned his telescope, after investigating the orbits of Jupiter's satellites, to other bodies of the system, and soon detected those most extraordinary appendages of the next planet, the rings of Saturn. The highest magnifying powers show these rings merely as thin luminous threads crossing the disk of the planet and projecting slightly beyond it at either side, but to the inhabitants of Saturn itself their appearance must be inconceivably grand. To the dwellers on one side of the planet the rings must present the magnificent spectacle of two vast luminous arches spanning the sky from horizon to horizon and rotating with enormous velocity; * and to the people on the other side the appearance will be the same, only that the arches will be dark instead of bright; while the regions which lie beneath their shadow will be plunged for fifteen years at a time in perpetual night. The feeble telescope with which Galileo discovered the rings only revealed to him two protuberances beyond the disk of the planet at the opposite ends of a diameter. They appeared to him to be detached bodies, and he was much surprised to find that they did not change their positions relatively to the planet, and therefore neither revolved round it nor rotated with it in its daily course. But extraordinary as this phenomenon appeared, it became still more so when these two objects gradually diminished in size, and finally disappeared altogether. Galileo was utterly baffled. "Is the legend of mythology," he asked in amazement, "no longer a fable, and has Saturn really devoured his children?" The explanation of course was that the planet, advancing in its course, and changing its position relatively to the earth, had brought its equator into the same plane with us, so that the rings only presented their narrow rim to us, instead of their broad flat surface. But it was not till long afterward that Huyghens, with improved telescopes, detected their real nature. Maupertius started a quaint theory for their origin. He supposed that they might be the mangled remains of an unfortunate comet, which had incautiously come too near Saturn, and got his tail wound round the planet and twisted off. A more probable theory we shall meet with further on.

Till within a comparatively recent period, these five planets, Mercury, Venus, Mars, Jupiter, and Saturn, were believed to be the only ones besides our own earth in the system, but in the year 1781 Uranus was added to the number by Sir William Herschel. He did not suspect at first that it was anything but a comet, but as every observatory in Europe immediately set to work to calculate its orbit, it was soon recognized as a planet. Herschel

* If it were not for this rotation they could not remain in equilibrium, but would be precipitated upon the surface of the planet.

wished to call it Georgium Sidus, after his kindly and munificent patron, George the Third. Several of his brother astronomers urged that it should be named after the illustrious discoverer himself, but the advocates of uniformity insisted upon the classical nomenclature being adhered to. The rival claims of all the old gods and goddesses were discussed. The name of Neptune found considerable favor in this country, Englishmen being then justly proud of the exploits of their fleet,* but the foreign astronomers would not agree to this. Many other names were suggested, and backed up by fanciful and epigrammatical reasons. Uranus was finally adopted, on the suggestion of Bode that the most distant of the planets might appropriately be called after the most ancient of the gods.

It was soon found that the planet had been observed no less than nineteen times before in different parts of the heavens, but from its great distance, and consequently insignificant apparent magnitude, it had always been mistaken for a star. This remarkable discovery excited the greatest interest among astronomers, and the hope began to be entertained that other distant planets also might have been mistaken for stars, and that the number of the planets might be thus still further added to. The only other discovery, however, which has yet been made of the character anticipated is that of Neptune, whose existence was first suspected by Bouvard in 1821, from the perturbations in the motions of Uranus caused by his disturbing influence. The problem of determining from these scanty data the distance, the orbit, and the mass of the disturbing planet, was evidently a possible one; but the analytical difficulties which it presented to the mathematician were so enormous, that for more than twenty years no one attempted to grapple with them. Our own University had the great honor of first undertaking the task, and of prosecuting it to a successful conclusion. Mr. Adams commenced his ever-memorable researches immediately after taking his degree in 1843, and on the last of September, 1845, his calculations of the place in which the supposed planet should be sought for were tendered at Greenwich Observatory. Before commencing the search, which was likely to prove a laborious one, the Astronomer Royal requested Mr. Adams to make some further calculations, with a view of confirming his results; † but while he was engaged on these, M. Le Verrier (who had been, unknown to both of them, employed in similar researches) published the results of his calculations on the first of June, 1846. As they agreed exactly with Mr. Adams, Professor Airy's hesitations were removed, and he wrote to Mr. Challis, recommending a careful search, with the great Northumberland refractor in the Cambridge Observatory. This advice was immediately followed, and an accurate map of the part of the heavens in question was commenced, with the hope that on a second survey, some star in it would be found to have changed its place, and thereby shown itself to be the planet sought for. But before this labor was completed, Dr. Galle, a Prussian astronomer, who had the advantage of having a good map already in his possession, found a new star not laid down in his chart; and

* Would the present Admiralty like to have a newly-discovered planet christened Megæra?

† Mr. Adams had based his calculations on the perturbations of Uranus in longitude, and Professor Airy suggested that he should examine whether those in radius vector would lead to the same results.

a little investigation established this at once as the long-sought-for orb. Professor Challis found that it was one of the bodies he had already mapped down, and that a few nights more must have infallibly led to its discovery by him also. Considerable jealousy was felt at the time between England and France with regard to the priority of claim between Adams and Le Verrier, the French astronomer being much disappointed to find that our countryman had vanquished the difficulty first, although his discovery was not made public at the time. But after all the question of priority is a small one; each of the astronomers completed the task by his own unaided genius, and the names of Adams and Le Verrier will be handed down to posterity with equal honor, as the solvers of the hardest mathematical problem which has yet engaged the attention of scientific men.*

No planet more distant than Neptune has yet been discovered; but about sixty tiny orbs have been added to the system, whose existence had been previously unsuspected—not from their distance, but from their minuteness. We allude of course to the asteroids. The history of their discovery is very interesting, and affords a remarkable contrast to that of Neptune; being the result of a bold and fortunate guess, while the other was the fruit of years of patient toil. Soon after the elements of the planets came to be accurately known, a remarkable empirical law was observed to connect their several distances from the sun. These were found to form a series, the difference between each of whose terms was twice as great as the preceding difference; in other words, the distance of any planet from the next without it was twice as great as its distance from the next within it. The only exception to this rule was in the case of Mars and Jupiter, whose distance from each other was much too great; in fact, it seemed as if there was a planet wanting between them to complete the perfect series. This fact, which was first noticed by the Baron de Zach, was considered so remarkable that a company of astronomers banded themselves together to institute a search for the missing orb, and shared out among themselves the part of the heavens in which it was expected to be found. The leading men of the day considered the idea as altogether chimerical, arguing with perfect truth that there was no reason to believe that the law in question was anything more than an accidental coincidence,† and that it was thus utter madness to attempt reasoning upon it at all. The madmen, however, pursued their quest; and, after a long and interesting search, the first of the asteroids was discovered; and shortly afterward, to the astonishment of everybody, a second, revolving in an orbit nearly coincident with that of the first. This remarkable departure

* The problem was the solution of a series of simultaneous partial differential equations with nine unknown quantities, namely, the mass, mean distance, eccentricity, epoch, and perihelion longitude of the unknown planet, and the corrections to the latter four elements of Uranus. The smallness of the perturbations in latitude showed that the inclinations and nodes might be neglected, or, otherwise, the number of unknown quantities would have been thirteen. Many of our readers will understand the impossibility of solving such a problem by any ordinary mathematical methods, and even the usual devices of the Planetary Theory, evolved by the genius of Laplace and Lagrange, failed in application in consequence of the inverse character of the problem. In fact, the old armory of Science was unavailable, and Adams and Le Verrier, in fighting their great battle with Nature, had to invent a fresh weapon for every stage of the conflict. For an interesting sketch of their labors we may refer our mathematical readers to Grant's "History of Astronomy," while the question of priority will be found discussed in Airy's "Historical Statement of Circumstances connected with the Discovery of the Planet beyond Uranus."

† It has since been found to be broken in the case of the planet Neptune.

from the established analogy of the whole solar system attracted universal attention; and when a third and a fourth asteroid had been discovered about the same place, Dr. Olbertz propounded the idea that the large planet which ought to have been found in this position had been, by some internal convulsion or by the shock of a comet, split into fragments—each of which was now pursuing its separate course as an independent orb about the great common centre of the system. This theory was at first almost universally received, being strikingly borne out by a remarkable fact with regard to the orbits of the then-discovered asteroids. If such a catastrophe occurred, the fragments would be hurled off in different directions and with different velocities, and would thus take up different orbits; but as the orbit of each would be ever the same, it follows that they would all at some period of their course pass again through the position from which they originally diverged. And this was found to be the case. There was a particular part of the heavens through which the four asteroids at one time or another passed, and which was therefore set down as having been the scene of the great original disruption. It was conjectured by some that the aërolites, or shooting stars, were small fragments from the same mass, which had been projected so far inward toward the sun as to come within the range of the earth's attraction, and be deflected down to its surface. This latter hypothesis received a good deal of support, being at least as probable as that of Laplace, which refers the origin of these meteors to volcanoes in the moon, and holds that they are hurled forth from those lunar craters with force sufficient to reach the earth. But the explosion theory is now itself exploded. Many of the more recently discovered asteroids do not pass near the place of the supposed disruption; and therefore, as we have seen, can never have been at that spot at all. It is true that the perturbations caused by the other planets would by this time have partially affected their orbits; but the discrepancy seems too great to be accounted for in this way, and the theory has now been generally abandoned. The only other attempt to account for the phenomenon of the asteroids is based upon the great Nebular Hypothesis of Laplace, which we shall explain hereafter.

These minor planets being all included within a belt of very moderate extent, it follows that large numbers of them will often be comparatively near together, and the appearance of the heavens at one of these will be peculiarly striking. Many bright planets will be scattered over every part of the firmament—some appearing as thin silver crescents like the new moon, some as half-moons, and others with fully illuminated disks; some so distant as to be indistinguishable from stars, and others surpassing the moon, itself in magnitude and splendor; their orbits crossing and overlapping in every direction, and the planets thus circling in and out among each other as if in the mazes of some majestic dance—some winging their flight far away to the most distant parts of their orbits beyond the sun, and others perhaps approaching so near as to fill half the firmament with their glorious blaze, and travelling along for days and weeks together, so near that their gigantic inhabitants might almost clear at a bold leap the airy gulf that separates their worlds from each other.

ASTROLOGY.

We can scarcely turn away from the subject of the romance of planetary astronomy without alluding to the mysterious influence which those bodies of our system were for many ages supposed to exert on the affairs of men. The science of astrology—for a science, and a most elaborate science it was—comprehended, of course, the other heavenly bodies as well as the planets. But although the sun and moon are far more important luminaries than the planets, and although the stars incomparably exceed them in number, yet the simple regularity of their movements rendered them far less interesting to the astrologer than the "wanderers" of the nightly sky. To the ancients, unfurnished with the master-key of Copernicus, the motions of the planets, with their fitful loops and backward sweeps, appeared altogether arbitrary and irregular, and these orbs were therefore naturally selected as those most fitted to represent the varying turns of Fortune's wheel, and to preside over the changing lots of men, of nations, and of the human race.

The origin of astrology, or the foretelling of events from the configuration of the heavenly bodies, is lost in the mists of a remote antiquity, but it was undoubtedly practised by the old Egyptian magi, before the time of Moses. The father of the written science was the illustrious Ptolemy, whose astronomical researches seem to have been prosecuted mainly for astrological purposes, and whose elaborate work, the Tetrabiblos, is the text-book of all succeeding votaries of the science. According to him, the planet in the ascendant at the time of birth was the chief ruler of the character and fortunes of the "native," as the entrant on this world's stage was technically called. Mercury presided over the mental faculties, and literary and scientific occupations. He caused a desire of change—though in this respect his influence was less than that of the moon—and a love of travelling. Venus was a benefic planet, styled the Lesser Fortune. She tended to produce a mild and benevolent disposition, with an inclination to pleasure and amusement; and her favoring influence brought good fortune to the native in his or her relations with the other sex. Mars, on the other hand, was the Lesser Infortune. His influence was not altogether evil, but he was decidedly risky, and needed to be well aspected by other planets to lead to any good. The man born under him was high-spirited, quarrelsome, and defiant of danger. The woman was probably a virago, or at the least what Ptolemy, if he had lived in a less favored age, would have been familiar with as "strong-minded." Mars, of course, ruled over warlike pursuits, and also over such trades as were concerned with iron and steel.

Jupiter was regarded as far the most propitious of all the heavenly orbs, and styled the Greater Fortune. He ruled all high and dignified offices, especially the church. The favored mortal born under him might be expected to prove high-minded and honorable; charitable and devout; liberal, wise, just, and virtuous. Happy the kingdom ruled by a sovereign on whose birth he shone! English astrologers of the present day tell with pride that our gracious Queen was born when Jupiter rode high in the heavens, right upon the meridian. So, they say was the Duke of Wellington; but as both the date and the place of his birth were uncertain, the astrologers must be as clever as Daniel—they cannot only interpret the dream, but supply it when forgotten. The Greater Fortune smiled also, though less brightly, on the birth of the Prince of Wales.

Next him we have the grim and ill-omened Saturn, the Greater Infortune; "and justly," says Lilly, "does he merit the title, being the cause, under Providence, of much misery." Those born under him are gloomy and reserved in character; faithful, indeed, in friendships, but bitter and unforgiving toward an enemy. Failure, disease, disgrace, and danger beset the steps of the child of Saturn with frequent and terrible pitfalls. The only pieces of good luck that appear to be attributable to him are the gloomy ones of legacies; while his special favorites are sextons, undertakers, and mutes. Of Uranus, of course, Ptolemy tells us nothing, but modern astrologers think him on the whole malefic. He causes eccentricity and abruptness of manners; and whether he brings good or evil, it is always of some peculiar and unexpected kind. We cannot find how Neptune is regarded by the astrologers; probably they have not yet made up their minds about him. But we may hope for his credit that Adams and Le Verrier, to whom he owes so much, are watched over by him with special favor.

Although the ascendant planet is the chief element to be considered in Genethlialogy, as Ptolemy styles the science of nativities, its influence may be modified by its combination with other planets, or its position in the zodiac. Thus, while Mars in general begets military men, they must, if he be in the watery sign of Cancer or of Pisces, find vent for their fighting tastes in the navy. And so on, from the soldier and sailor, through the "tinker, tailor, ploughboy, and apothecary," down to the "thief," who is born under the moon, "afflicted by Mars." The tailor is the only one of the list we cannot trace. Probably, from his fractional character, he belongs to one of the asteroids.

The signs of the zodiac were supposed to have a good deal to do with personal appearance. Thus Pisces produced a short figure, pale and fleshy face, round shoulders, and a heavy gait; Taurus a well-set person, with broad face and thick neck; and so on. If parts of two signs occupied the ascendant together, a portion of the body would belong to one sign and the rest to another. Wild as the whole system of astrology is, it seems especially strange that the great philosophers of antiquity should have thought that human fortunes could be swayed, not merely by the constellations themselves, but by the arbitrary and fanciful names which men chose to assign to them.

Definite portions of human life were allotted to the different luminaries: infancy to the moon; childhood to Mercury; youth to Venus; the vigor of manhood to Mars; maturer age to Jupiter; aad second childhood to the ominous Saturn. And lastly, the visible firmament was divided into twelve equal portions, meeting in the zenith. The first was the house of health; the second that of wealth; the third that of brothers and sisters, and also of short journeys, the latter being probably put in to fill up the space if the former should be wanting; the fourth that of parents; the fifth that of children and of amusements; the sixth that of sickness; the seventh that of love and marriage; the eighth that of death; the ninth that of scientific pursuits and distant journeys; the tenth that of trade or calling; the eleventh that of friends; the twelfth that of enemies. The connection of these houses with the rest of the system is, of course, obvious. Thus Saturn in the fifth house foretells misfortune with one's children; Mercury in the sixth house, mental disease; and Mars in the eighth house, a violent death.

Probably few persons have their horoscopes erected nowadays, but we have before us that of the Prince of Wales, calculated at the time of his birth by Zadkiel, according to Ptolemy's rules. The Prince was born at forty-eight minutes past ten, on the morning of the 9th of November, 1841, at Buckingham Palace, lat. 51° 32′ N., long. 6′ W. The sign in the ascendant was Sagittarius, which, in Ptolemy's words, produces "a tall upright body, oval face, ruddy complexion (with a tendency to duskiness), chestnut hair, much beard, good eye, courteous, fair-conditioned, noble deportment, just, a lover of horses, accomplished, and deserving of respect." The Sun, being well aspected, prognosticated honors; and as he was in Cancer, in sextile with Mars, the Prince was to be partial to maritime affairs, and win naval glory. The house of wealth was occupied by Jupiter, aspected by Saturn; and this, as we have already seen, betokened "great wealth through inheritance"—a prognostication which, in spite of republican shoemakers and baronets, is not unlikely to come true. The house of marriage was unsettled by the conflicting influences of Venus, Mars, and Saturn, but fortunately the latter was to predominate, and the Prince, "after some trouble in his matrimonial speculations," was to marry a princess of high birth, and one not undeserving of his kindest and most affectionate attention. His marriage was to be expected in 1862. There are few other predictions of particular events; the one put forth with most confidence is that of an injury from a horse in May, 1870, when Saturn is exactly stationary in the ascending degree. Zadkiel says, however, that this evil might be guarded against by prudence, which we presume was done, as the accident did not come off. There was also danger of a blow on the left side of the head, near the ear; but it does not appear whether this was to be administered by the horse, or to be a separate accident. The house of sickness showed a predisposition to fever and to epileptic attacks. The position of Saturn in Capricorn betokened some loss or disaster to the native in one or other of the places specially ruled over by Capricorn; which we find from a table to be Brussels, India, Greece, Mexico, part of Persia, the Orkney Islands, and Oxford. We hope that the place indicated was the last of these, as if so the disaster is probably well over by this time, and was nothing more serious than some slight scrape with the authorities of Christ Church.

But while we have few particulars about the Prince's history, we are overwhelmed with information about his character. Each planet contributes an enormous list of characteristics, depending on its position and aspects at the moment of birth. When put together, they give the somewhat complex character which we subjoin. The infant Prince was to turn out "acute, affectionate, amiable, amorous, austere, avaricious, beneficent, benevolent, brave, brilliant, calculated for government, candid, careful of his person, careless, compassionate, courteous (twice over), delighting in eloquence, discreet, envious, fond of glory, fond of learning, fond of music, fond of poetry, fond of sport, fond of the arts and sciences, frank, full of expedients, generous (three times), gracious, honorable, hostile to crime, imperious, ingenious, inoffensive, joyous, just (twice), laborious, liberal, lofty, magnanimous, modest, noble, not easy to be understood, parsimonious, pious (twice), profound in opinion, prone to regret his acts, prudent, rash, religious, reverent, self-confident, sincere, singular in mode of thinking, strong, temperate, unreserved, unsteady, valuable in friendship, variable, versatile, violent, volatile, wily, and worthy." It will be seen that the good qualities largely predominate ; the bad ones are due to Saturn, who of course must have his envious cut, but who is happily pretty well kept down by the cumulative influence of the propitious planets.

Zadkiel finishes thus : "The square of Saturn to the Moon will add to the gloomy side of the picture, and give a tinge of melancholy at times to the native's character, and also a disposition to look at the dark side of things and lead him to despondency ; nor will he be at all of a sanguine character, but cool and calculating, though occasionally rash. Yet, all things considered, though firm, and sometimes positive in opinion, this royal native, if he live to mount the throne, will sway the sceptre of these realms in moderation and justice, and be a pious and benevolent man, and a merciful sovereign."

God grant that it may be so, and that the life, so recently spared in answer to a nation's prayers, may, while crowned with every good and perfect gift itself, be blessed to the promotion of that nation's truest welfare !

THE MOON.

Passing now from the planets to the other bodies of the solar system, we turn in the first place to our next-door neighbor, the moon. While the interest with which we view the planets arises from their close analogy and consequently great probable similarity to ourselves, that attaching to the moon is caused mainly by its remarkable proximity to us, and the clear view which we accordingly have of its surface and configuration. It is, in fact, the only one among all the heavenly bodies of whose state and constitution we can ever hope to learn much by actual observation. With regard to the rest we must for the most part reason from analogy alone, and hence we can seldom arrive at any results of which absolute certainty can be predicated. With the moon, on the other hand, we have ocular demonstration ; and though we do not know very much about it—not half so much as we should like—still what we *do* know we can be perfectly certain of, and that is a very great matter indeed.

Before we touch at all upon the vexed and difficult questions of the existence or non-existence of a lunar atmosphere, lunar seas, and lunar inhabitants, we may glance in the first place over those points of interest which depend simply upon the position and movements of the moon—points therefore in the determining of which there can be no difficulty, and about the results of which there can be no difference of opinion. The first ideas which the ancients conceived of the nature and constitution of the moon were very wide indeed of the truth. The old Chaldean astronomers supposed that it was a globe, one half of which was made of fire, and which, by revolving upon its axis, presented its different sides to us in succession. This idea accounted sufficiently well for the phases exhibited by it ; it was, however, anything but a probable one in itself ; and when Thales observed the fact that the bright portion of the moon is always that which is turned at once to the sun and to ourselves, the old hypothesis was at once exploded, and the true explanation —that our satellite shines with reflected solar light—came to be universally received. Next to the phases of the moon, the most noticeable point about the appearance which it presents to us, is the fact that the configuration of its surface is always the same. From our earliest childhood that configuration, with its quaint resemblance to a human face, has been familiar to all of us ; the large eyes and arched eyebrows of the "man in the moon," his irregular nose, and his long melancholy mouth are among our first recollections of the nightly sky. Nor is the idea only a tradition of the nursery. It is of the most venerable antiquity (though the ancients assigned to the moon's face a softer sex than we do) ; for we find in Plutarch the following quotation from a very early Greek poet, Agesianax, whose works are lost :

> *πᾶσα μὲν ἥδε πέριξ πυρὶ λάμπεταἕ, ἐν δ' ἄρα μέσση*
> *γλαυκότεοον κυάνοιο φαείνεται ἠύτε κοῦρος*
> *ὄμμα καὶ ὑγρά μέτωπα τὸ δ' ἐρυθρον ἄντα ἔοικεν*—

lines which Amyot translates thus :

> De feu luisant elle est environnée,
> Tout à l'entour ; la face enluminée
> D'une pucelle apparoit au milieu,
> De qui l'œil semble être plus vert que bleu—
> La joue un peu de rouge colorée.*

The earliest attempt at explaining the fact that the moon's surface presents a constant appearance to us, notwithstanding its revolution round us, is found in Clearchus, a follower of Aristotle, who says that "the moon must be the most beautiful and perfect mirror, in regard to smooth polish and lustre, in the world ; for that in it we see to appear reflected the images and figures of our great continents and oceans." A little consideration sufficed to show that this hypothesis, besides its inherent improbability, was insufficient to account for the phenomenon in question ; and astronomers were shut up to the conclusion that the moon rotates on its own axis in a period exactly equal to that of its revolution about the earth. This perfect agreement of two periods so independent of each other (in the case of the earth, for example, the

> * Over the orb shines a resplendent light,
> In midst of which a damsel's face is seen ;
> Whose cheeks suffused display her blushes bright—
> Her eye cerulean, or a pale sea-green.

angular motion about the axis is 365 times as rapid as that in the orbit) was long regarded as the most marvellous coincidence in the economy of nature; but a recent ingenious mechanical explanation, too difficult to be given here, has cleared away a good deal of its *à priori* improbability.*

The idea of Clearchus about the moon being a mirror was revived in a singular manner in the middle ages. Some pseudo-philosophers maintained the possibility of communicating between distant parts of the earth by reflection at the surface of its satellite. "Do we not," they said, "see objects sometimes reflected by mirrors, even in positions in which, by reason of the interposition of screens, we cannot see them direct? Accordingly, writing on paper, either in characters of the ordinary size, or magnified by optical arrangements, might be reflected up to the moon and from thence be transmitted to some point of the earth. They might then be magnified by some means so as to become visible."

The necromancer Agrippa had the effrontery to maintain that he had actually communicated in this manner with the distant east. Nothing goes down so readily with the ignorant as a good round lie, coated with a flimsy varnish of science; and, accordingly, these marvellous asseverations were received with very general credence, and the scientific men of the day found considerable difficulty in combating them. The energy with which they controverted these fabrications made them perhaps the less ready to detect the grain of truth which lay concealed under the mass of fiction. The faint ashy light which irradiates the dark part of the lunar disk, and which produces the appearance familiarly known as "the old moon in the young moon's arms," was long a matter of discussion and debate among astronomers. Some supposed that the moon's surface was slightly self-luminous, others that its mass was partially transparent, and that the sun's rays penetrated to a small extent through it. But both these theories were disproved by the fact that in a total eclipse the ashy light was altogether wanting. It was reserved for an amateur—the painter Leonardo da Vinci—to suggest the real explanation—namely, that the illumination was produced by the sun's rays being reflected from the earth's surface to the moon's and back again to the earth. The astronomers gladly availed themselves of the suggestion, and being once put upon the right track, they had little difficulty in showing that it presented a most perfect accordance with facts. It need not surprise us that the sun's light, even after two reflections, should remain bright enough to be discerned by the eye. When we consider the brilliant illumination which our own surface receives on a clear night from the full moon, it is evident that it must be quite possible for the lunar inhabitants to see their own light reflected back to them from us. And as the earth is so much larger than the moon, the effect will clearly be increased in proportion when we take the case of our light returned to us from them. The general aspect of the heavens from the surface of the moon will not be very different from what it appears to us. The sun will be, of course, the great luminary in their firmament as it is in ours;

* It has been shown that if the two periods were originally at all nearly equal, the attraction of the earth on the protuberant parts of the moon would tend to bring them in time to exact equality. See Arago's "Astronomy," vol. ii. p. 283; Routh's "Rigid Dynamics," p. 449. The same peculiarity has since been found to hold in the case of the satellites of Jupiter and one of those of Saturn.

and the great source of lunar—as of terrestrial—light and heat. The nightly revolutions of the stars also will be the same, and the place the moon itself occupies in our nocturnal firmament will be supplied to it by the earth, which will present the appearance of a splendid moon, thirteen times larger than the sun. Its revolution on its axis will present its different faces to the moon in rapid succession, and when our sky is free from clouds, the configuration of land and water on our surface will probably be clearly visible to the lunar inhabitants. They must know more of our circumpolar regions than we do, and could doubtless tell us whether there is open sea around the north pole; though, unless their telescopes are much more powerful than ours, they could not settle the question of the legendary Scotchman.

This great orb will appear immovably fixed in one particular part of the heavens, while the stars pass slowly beside and behind it. It will display the same phases, and cause and suffer the same eclipses, that our moon does. It is scarcely proper perhaps to speak of our suffering any eclipse from the moon at all; for the shadow of that body is so small that it will never cover any large part of our surface, and will in fact appear only as a small black circle passing slowly across our disk. But solar eclipses on the other hand will be at the moon far more frequent and striking phenomena than they are here. From the large size of the body behind which the sun appears to pass, a total eclipse will sometimes last as long as four or five hours, during which time the whole surface of the moon will be plunged in midnight darkness.

In consequence of the slow rotation of the moon upon its axis, its day and night must each be a fortnight long; and as its year is just the same length as ours, each of its seasons must consist of only three days and three nights. But the distinction of the seasons will be much less there than on the earth, and will besides be almost entirely lost in the far greater difference between night and day. If the atmosphere at the other side of the moon be as attenuated as it is at that which is turned toward us, this fact, combined with the great length of time for which the sun continues above or below the horizon, will render the lunar days more scorching than the sirocco, and its nights colder than the frigid zone; and thus each of its long days will be in reality a summer, and every night a winter—the morning twilight spring, and the evening twilight autumn. The hemisphere turned toward the sun, or the part of the moon which appears bright to us, must have any moisture which it may contain dried up by his vertical beams; while on the other, or dark side, the ground must be frozen hard to the depth of several feet, the mountains covered with glaciers, and the seas blocked up with icebergs. At the very margin between the two hemispheres there will be a narrow temperate zone, which will of course move round the moon, as the latter turns round its axis and presents its different faces successively to the sun; and the only way in which we can see that life could be supported with comfort at the moon (supposing the atmospherical difficulty surmounted) would be by moving constantly round it, so as to keep always in this temperate zone. A queer Noah's Ark-like sight it would be to see the whole inhabitants of the moon, side by side, in a huge procession extending from pole to pole, and hurrying quickly round it at the rate of ten miles an hour—some riding, some driving, and some travelling in slow railway trains; beasts, wild and tame, galloping by their side, and all the birds of heaven flying along over their heads!

But this brings us to the great question whether the moon can really have any inhabitants or not. Of all the problems which the science of astronomy is called upon to answer, none perhaps is possessed of deeper or more general interest than that of the plurality or non-plurality of worlds. We have all often wondered, as we have gazed on the star-spangled sky, whether those distant orbs are teeming hives of busy life like our own, or whether all the inhabitants of the universe have been indeed collected upon this one tiny and insignificant ball. And as the moon is the only one of the heavenly bodies with regard to which there has ever been a chance of arriving at any positive and definite evidence upon this subject, it follows that upon it have been concentrated almost all the researches and arguments of astronomers on the point. We can fancy the eagerness with which Galileo first turned his tiny telescope to its mottled face, and his disappointment when he found himself unrewarded by any revelations of life at its surface. And as the instrument has received each fresh accession of magnifying power from his day to our own, every succeeding observer has felt the same anxiety and experienced the same disappointment. Kepler thought that he saw, in the regular circular valleys with which the moon's surface is so closely dotted, artificial excavations, under the sides of which the inhabitants sheltered themselves during their long and scorching days; but when he found on measurement how large the dimensions of some of these craters were, he was compelled to abandon the idea. Even within the last half-century, an eminent German observer, in using a new and powerful telescope, fancied that he had discovered a series of colossal fortifications in one part of the moon's surface, closely resembling the gigantic wall which the Chinese have erected against the outside barbarians. But these lunar ramparts could not stand against the tide of optical improvements, and the next big telescope showed them to be only basaltic formations, though of such singular regularity that their first observer might well be excused for attributing to them an artificial origin.

The fact is, that no satisfactory traces of inhabitants or of their works have ever been detected upon our satellite. The smallest space that can be distinctly seen with the best telescope at the surface of the moon is a circle of about a mile in diameter, and therefore no ordinary creation of human hands could be seen with sufficient clearness to place its character beyond doubt.

An old philosopher suggested, half in earnest and half in jest, a method of settling the point, which certainly possessed at least the merit of ingenuity. He argued that any race of rational beings must have discovered the leading principles of geometry, and would doubtless be aware that the square on the hypothenuse of a right-angled triangle is equal to the sum of the squares in its sides. He therefore suggested that a huge figure of the forty-seventh proposition of Euclid should be built on some great plain on the earth's surface. If the moon were inhabited by rational beings, they would be sure to recognize it as an old friend, and would doubtless divine that their terrestrial brethren were wishing to open communication with them. They would accordingly reply by the construction of some other important mathematical diagram—possibly, if their geometry is in advance of ours, they might send us down a method of squaring the circle. Thus we should at once have settled the existence of lunar inhabitants, and started a method of communicating with them. Probably our next move would have been to construct the figure of a man, to show our new friends what we were like, and to hint that we should be glad to know something of them.

An improvement upon this suggestion was that enormous bonfires should be simultaneously kindled at points on the earth's surface forming the angles of a regular polygon. The symmetry of this phenomenon would strike the people in the moon with the idea of design, and suggest to them the existence of terrestrial inhabitants; and they would doubtless make known to us in return their own existence by some similar device. But neither of these experiments was tried, and neither of them is likely to be tried now; for in more recent periods some delicate investigations have thrown serious objections in the way of the inhabitant theory, by proving almost beyond a doubt the lack of water, and of all but an extremely attenuated atmosphere, on, at any rate, that side of the moon which is turned toward us. These conclusions were resisted as long as possible by Sir David Brewster, and other enthusiastic patrons of the "Selenites," or "men in the moon;" but latterly the weight of proof was becoming fairly too strong for them, and they were being obliged to take refuge in the somewhat unsatisfactory argument that after all the Selenites might be so constituted that they could get on without either water of air.

But about fifteen years ago a great deal of light was thrown upon the subject from a new and most unexpected quarter—light that filled Sir David Brewster and his friends with extreme exultation, and carried confusion into the ranks of those who had too hastily triumphed over them. It was discovered, on the occasion of a certain eclipse, that the moon was no less than three seconds behind its time in touching the sun's disk!

What connection a fact like this has with the question of the moon's being inhabited or not it is not at first easy to see, but we shall find that it is really connected with it in the closest manner, and that in fact it clears out of the way all the objections which have ever been started against the moon's capability of supporting animal life at its surface. Of course it was not to be thought of for a moment that so great a discrepancy between fact and theory as that mentioned above should be allowed to remain unexplained. An express train on a journey of an hour's length would be granted at least a couple of minutes' grace, but not even three seconds could be allowed the moon after its long circuit of nearly a million miles. All the astronomers, both of this country and of the continent, were soon engaged on the question; and as it was proved that the observed irregularity was not due to the disturbing influence of any other body, they concluded erelong that it must arise from something anomalous in the figure or constitution of the moon itself. After an elaborate analysis, Professor Hansen, of Gotha, found that it could be accounted for only by supposing that the side of the moon nearest us was lighter than the other, and hence that its centre of gravity—or the point to which any object on its surface would be attracted—was not at its centre of figure, but considerably nearer the side of it which is always turned away from us. He calculates the distance between these centres to be nearly thirty-five miles, evidently a most important eccentricity, when we remember that the radius of the moon is little over a thousand miles. It must have been produced by some great internal convulsion after the moon assumed its solid state; but the forces required to produce this disruption are less than might at first sight appear necessary, owing to the fact that the force of gravitation, and the weight of matter, are six times less at the moon than with us.

From this peculiarity of the moon it follows that any fluid substance at its surface, in its attempt to get as near as possible to the centre of gravity, must have flowed round to the other side, and taken up a position of equilibrium there—just as a drop of water let fall upon a smooth globe of any kind would trickle round it and hang suspended from the lowest point. In fact, we can readily see that the circumstances at the part of the moon nearest to the earth must be the same as at the summit of a mountain on our own globe more than two hundred miles high; and we know that at such an elevation as that, the atmosphere would be so rare as to be utterly indistinguishable. At the edges of the moon's visible disk, the conditions would be the same as at a considerable altitude on the sides of such a mountain. And as we find from actual observation that there really is a certain attenuated atmosphere at those parts of the moon's surface, we are led to the unquestionable conclusion that on its other side, which would correspond to the level surface of the earth, the atmosphere must attain a very considerable density, such as we have every reason to suppose would render it perfectly well fitted for the support of animal life.

The water difficulty is got over in a similar manner. It is true that when the seas flowed away from the side of the moon next us, large bodies of water would be left behind in lakes and in the depths of the ocean. But the withdrawal of the atmosphere would lead to their immediate evaporation, and as soon as they were converted into vapor, they too would be free to gravitate round to the other side. Indeed, the visible disk of the moon presents every appearance of having been, in former ages, to a great extent under water. Its enormous level plains surrounded by lofty mountains, its huge basins or craters opening everywhere among the rocks, and the vast ravines dividing its mountain-chains, are altogether unlike our terrestrial scenery; but they are exactly similar to what we should see if all our oceans, lakes, and rivers were dried up, and their beds laid bare. In fact, we can scarcely doubt that there were formerly great bodies of water on this side of the moon; and if there were, it is equally certain that they must now be upon the other side.

We see, then, that we might have predicted *à priori* the absence of air and water from this side of the moon; we see also that there must be air, that there probably is water, and that there is no reason why there should not be inhabitants upon the other side. Astronomy thus clears away the difficulties it had itself raised in the way of the habitability of the moon;

further than this it cannot go; no telescopes can ever pierce through the solid body of the moon and reveal the secrets of its further surface. Science has done all that can be expected at its hands when it has proved the complete possibility of a plurality of worlds, and the remainder of the question must be handed over to the inductive philosopher and to the natural theologian, to be judged of, as we have already said, by analogy, and by a consideration of what we otherwise know of the general economy of Providence. This part of the argument falls without our sphere—it belongs to the Religion of astronomy, and not to its Romance. The arguments, however, in favor of the plurality of worlds are patent to every one, and each of us may arrive for himself at what conclusion he pleases upon it. For our part, we cannot bring ourselves to think that our own globe is the only inhabited one in the universe. Besides the *primâ facie* improbability that a small and insignificant planet should be in reality the most important body in creation, we think it is utterly impossible, on any common-sense grounds whatever, to believe that the larger and more distant orbs that spangle our firmament should have been created for our sakes at all. If their object were to afford us light, this purpose might have been far more effectually served by giving us another moon not a thousandth part as large as any of them; if it were to beautify our celestial scenery, this end, too, would have been equally attained by fixing some small luminous bodies within the limits even of our own atmosphere, instead of by placing these gigantic spheres at such incalculable distances from us. Nor is it probable that the Divine Architect should have created them for his own contemplation and that of the angelic hosts alone. It is contrary to the whole analogy of nature, and repugnant to all the ideas of the Divine wisdom and goodness which we have been accustomed to entertain, to think that these mighty orbs should have been framed for no other end than this. In all the economy of Nature we find nothing like waste of material or aimless expenditure of creative power; and while we see every blade of grass around us furnished with inhabitants and every drop of water teeming with a world of its own, it seems impossible to believe that those glorious stars should be in reality nothing more than so many waste and gloomy deserts.

Before we pass on to the next part of our subject, let us glance for a moment at a singular train of speculation suggested by a fact mentioned above—that, namely, of the eccentric gravitation at the moon. We have seen that any object at the surface of that body will be attracted not toward the centre, but to a point at a considerable distance from it. This eccentricity, though enough to bring all the lunar atmosphere and water round to the heavier side, will yet probably be insufficient to cause any serious practical inconvenience to the dwellers upon its surface; but if it were carried to a somewhat greater extent, the results would be very singular. The reason why the natural position of any object at the surface of the earth is an upright and not a slanting one, is that the centre of gravity being exactly beneath our feet, the direction of its attracting influence is of course perpendicular to the surface. But if the centre of gravity were removed somewhat to one side, its attraction would now be oblique, and all formerly upright objects, such as men, buildings, and trees, would be compelled to take up a slanting position in order to the preservation of their equilibrium, while any round and easily movable body would immediately bound off in the direction of the new centre. Practically speaking, this state of affairs would be much the same as if the level surface were suddenly, and without any change on itself, transformed into a steep hillside ; for on such a surface, though at right-angles to the sea-level, we yet occupy a sloping position relatively to the face of the hill. But the eye would doubtless inform us that we were upon a level surface ; and, in fact, in order to arrive at an idea of the matter, we must combine the appearance of a level plain with all the properties of a steep incline. At the part of the surface nearest the centre of gravity, this "slantindicular" state of things, as the Yankees would call it, would be especially singular. Though the surface all round would be evidently level, yet to whatever side we started off the feeling would be the same as if we began to ascend a steep hill ; and while at the central spot a man would stand upright, when he walked away in any direction his head would seem to go faster than his feet, till he took up his natural inclined position. In fact, to use a slang expression in a strictly literal sense, it would be a regular case of "sloping off."

THE SUN.

THE next of the heavenly bodies which claims our attention is the great centre of the system itself. When seen with the naked eye, the uniform and dazzling brilliancy of the sun's disk prevents us from getting any idea of the configuration of his surface, as we can do in the case of the moon ; and even when viewed through a telescope, the overpowering brightness of the greater part of it renders it impossible to distinguish anything of the surface from which that intense illumination proceeds : just as when the eye catches the glare from a fragment of glass lying in the sunshine, it sees only the light proceeding from it, while of the object itself it sees nothing. But fortunately for astronomers, the brightness of the sun's disk is not altogether uniform, and by a contemplation of those remarkable phenomena known as the solar spots, they have been able to arrive at an idea, and no doubt an approximately correct one, of the nature and constitution of this extraordinary luminary. The spots on the sun, though varying much in size and shape, yet in their general appearance partake very much of the same character. They consist of a black central spot or nucleus, surrounded by a well-defined fringe less dark in color, which is known as the penumbra. Sometimes the nucleus is absent, more rarely the penumbra ; but the great majority of solar spots show both. Round their edges there are generally seen small patches of light of intense brilliancy, surpassing even the ordinary radiance of the sun's disk : these are called faculæ. The spots are by no means permanent, but undergo changes, and often very rapid ones, in magnitude and position ; while after a comparatively limited period they close up and disappear altogether, to be succeeded by new ones, and those again by others, in varying and never-ending succession.

The discovery of the spots on the sun was as stoutly resisted by the metaphysicians as those of Jupiter's satellites and the earth's orbital revolution. They could not in this case, like the superiors of the Inquisition, twist Scripture into contradiction with facts; but they took their ground on what with them was a still higher authority, the dictum of Aristotle. The illustrious Stagyrite had proclaimed the heavens incorruptible and immutable; it was beneath the dignity of the great orb of day to be affected by any physical changes such as our paltry planet is subject to. The Jesuit Scheiner, one of the earliest observers of the solar spots, was prevented by his provincial superior from publishing his results. "I have," says he, "read Aristotle's writings from end to end many times, and I can assure you that I have nowhere found in them anything similar to what you mention. Go, my son, and tranquillize yourself; be assured that what you take for spots in the sun are the faults of your glasses or your eyes." But other glasses and other eyes gave the same results, and only the most bigoted of Peripaticians could deny that their master's infallibility had received its death-blow.

The next discovery was a most important one. It was found that any individual spot, if it did not break up, moved across the sun's disk in a period of about fifteen days; that it then disappeared, and after an equal interval presented itself again on the opposite edge. This evidently pointed to one of two conclusions. Either the spots were solid bodies revolving round the sun, or else that luminary had himself a motion about an axis and carried his spots round with him. Scheiner and some other astronomers leant to the former hypothesis, but the latter was soon received as the correct one and numerous theories were started as to what the nature of the spots really was. Galileo supposed them to be clouds. La Hire imagined that they were huge cinders from the burning body of the sun, rising to the surface of the fiery ocean which surrounded it, floating for a time upon it, and then being again ingulfed within it to rise a second time in another place. Derham and Wollaston referred them to volcanic agency, supposing that they were great clouds of smoke and scoriæ ejected from craters in a state of eruption, and that the faculæ consisted of flames and streams of molten lava. The least improbable hypothesis was that of Lalande, who believed them to be high mountains rising above the general solid surface of the sun, and sometimes covered, sometimes laid bare, as the tides and waves of the solar sea surged backward and forward around them.

But about a hundred years ago Dr. Wilson, of Glasgow, established from simple optical considerations, the fact that the spots are depressions below the general luminous surface, and not eminences above it. It also came to be recognized that the rapidity of their fluctuations, and the gigantic scale on which they take place, are incompatible with anything but a gaseous state of existence. Accordingly the old idea of a luminous liquid ocean was discarded; and the following theory, propounded by Sir William Herschel, is now, in its main points, almost universally received. He supposes that the sun has two separate atmospherical strata, or rather gaseous envelopes of cloud-like consistency, both several thousand miles in thickness; the outer one—the photosphere, or source of the solar light and heat—being of some extraordinarily phosphorescent character, while the inner one is non-luminous in itself, but possessed of a highly reflective surface. Upon this theory the spots are caused by atmospherical agitations on a most enormous scale. A huge chasm, sometimes not less than fifty thousand miles in diameter, opens in the outer stratum, while a corresponding rift of lesser size in the inner one reveals the dark body of the sun itself behind. This accordingly constitutes the black nucleus of the spot, while the penumbra is caused by the light from the luminous atmosphere being reflected back to the eye from the surface of the inner one. If, as not infrequently happens, the rift in the photosphere does not extend through the inner envelope, the spot will be all penumbra without a nucleus. And when we have the rarer occurrence of the inner opening exceeding the outer in size, the whole spot will be uniformly black. The phenomenon of the faculæ, which Dr. Wilson showed to be great prominences or waves on the photosphere, is due to the piling up of the luminous matter thrown out from these gigantic chasms.

Not to enter further into details, which would be familiar to scientific readers and irksome to others, we may just say that this theory accounts in the most satisfactory manner not only for all the changing phenomena of the spots, but for other remarkable peculiarities which have been detected upon the sun's disk. Sir John Herschel has completed his illustrious father's theory by suggesting the probable physical cause of these convulsions in the solar atmosphere. He supposes them to be analogous to those terrible whirlwinds or rotatory storms which form so appalling a feature in the meteorology of our own tropical regions. Into this theory also it is impossible to enter in detail; but the whirlpool-like appearance of the spots, the situation of them all within a small distance from the sun's equator, their apparent rotation about an axis of their own, and the direction in which they move along the solar disk, all bear out Sir John Herschel's explanation in the fullest and most satisfactory manner. A *prima facie* objection to his theory is that the terrestrial whirlwinds are caused by the great differences of temperature between the equatorial and other regions of the earth's surface, and that as the sun is the source of his own heat, there is no reason why such differences should exist in his case. But Herschel meets this objection by an ingenious answer. The sun has an ordinary non-luminous atmosphere of great extent, exterior to the photosphere; and his rotation on his axis will cause this atmosphere to bulge out considerably round the equator. And this greater depth of atmosphere, by retarding radiation from the equatorial regions, will give rise to the differences of temperature which the theory assumes.

Our knowledge of the physical constitution of the sun has been greatly increased within the last few years by the wonderful revelations of that most powerful engine of physical research, the spectroscope. A careful analysis of the solar spectrum formed by a prism, and a comparison of it with the spectra of terrestrial elements in a state of incandescence, reveal to us the presence in the solar atmosphere of many familiar substances, such as hydrogen, and the vapors of iron, sodium, and other metals. Line for line the solar spectrum agrees with the known peculiarities of elements which form constituents of our own globe, and we have the interesting fact established that the gorgeous parent of our system is, so to speak, bone of our bone and flesh of our flesh. The same powerful analysis, when extended to the stars, discloses similar results; and we are led to the inference that our own tiny globe, though such an insignificant fraction of the universe, contains, represented within its narrow bounds, all the materials of which that gorgeous system is built up. Unfortunately the spectroscope can tell us nothing of our own satellite, though it is so much the nearest and most distinctly visible of all the orbs of heaven. Moonlight is simply reflected sunlight; and hence its spectrum is, as we should expect, but a faint reproduction of the more brilliant solar one.

The spectroscope has lately been applied successfully to those singularly beautiful phenomena which accompany a total solar eclipse, and which are generally known as the rose-colored protuberances. As soon as the sun's light is wholly cut off by the moon, cloud-like prominences, of a bright roseate hue are seen projecting from its surface beyond the moon's edge; and occasionally traces of a layer of the same material are seen at their bases, which lead us to suppose that the whole sun is encompassed by a ring of this matter. Whether it is a distinct solar envelope, or only a part of the photosphere, is at present uncertain; but pending the settling of the doubt, it has received the specific name of the chromosphere. The spectroscope shows it to consist of incandescent gas, of which hydrogen is the chief constituent; and the rose-colored protuberances are huge masses of this flaming substance, which have been hurled up into the solar atmosphere to a height, sometimes, of fifty or a hundred thousand miles above their ordinary bed.

Another interesting phenomenon which appears at the time of a total eclipse is the solar corona—a great halo of light surrounding the darkened sun and stretching far out into space. This halo was at first supposed, naturally enough, to be the solar atmosphere, lighted up by the sun's rays streaming through it and imparting to it a portion of his own effulgence. But here again the spectroscope comes to our aid. It tells us the degree of pressure to which the incandescent hydrogen composing the rose-colored protuberances is subjected, and shows the impossibility of their being burdened by such an enormous atmosphere as the whole corona would represent. The progress of modern science has left little doubt as to its real nature. We have learned that the whole solar system is traversed by numberless tiny planetoids, some moving singly, others in small clusters, and others in enormous groups containing countless myriads of these little units. These aërolites pursue their proper paths about the sun as truly as the largest bodies of the system, save when they get entangled in the atmosphere of our own or any of the other planets. When this is the case, the sudden checking of their enormous velocities by the resistance of the air reduces them instantly to a state of incandescence, and we see them flashing across our firmament as shooting stars, the next moment to be dissipated into vapor. The periodical meteoric showers of August and November are caused by our orbit carrying us, at those periods of the year, right through great clusters of these aërolites. It has been estimated that not less than a hundred thousand million of them are annually caught by our atmosphere; and when we consider the comparative smallness of the ring which we traverse, we can see that the absolute number of the meteorolites belonging to our system must be something incomparably exceeding the highest flights of human calculation. In the immediate neighborhood of the sun, where his attraction exercises the most direct and potent influence, they will be found in special abundance; and it is to the fact of their existence that we must look for an explanation of the corona, and perhaps of yet greater and more interesting mysteries of our system. The corona is simply the sunlight reflected from their surfaces, as it is from the disks of the moon and planets. For a vast distance round the sun the whole firmament is powdered with them as thick as hailstones, and the reflection from them produces a continuous luminous glow, lost indeed in the overpowering brightness of ordinary sunlight, but shining out with exquisite lustre when his direct beams are cut off from us.*

These meteorolites have played a most prominent part in the scientific speculations of the last twenty or thirty years. The meteoric theory of the sun's heat was first propounded by Dr. Mayer, a German physician of great scientific attainments, and was warmly espoused and worked out by Sir William Thompson. There can be no doubt that the sun is constantly receiving great accessions of heat from the meteoric fragments which compose his corona. Countless myriads of them rain into his atmosphere every instant, with a force sufficient to convert their solid mass into a puff of vapor; and it was for some time thought that the heat derived from these terrific impacts might keep the solar envelope ever ablaze with undiminished intensity. No grander or more striking theory has ever been propounded in the history of astronomy. That the mighty centre of our system should recruit his marvellous expenditure of energy from the tiniest of his satellites; that these fragments, each so insignificant in itself, should collectively supply light and heat and life to the great Sun himself, and through him to all his attendant orbs; that it should be through their agency that the Creator of the universe has ordained that all His creatures should live and move and have their being—is one of the most striking conceptions that can possibly be imagined. But more recent observations have led Sir William Thompson to a modification of his theory. He has calculated that if the meteoric shower were sufficiently heavy to make up for the sun's whole expenditure of heat, the matter of the corona must be so dense as seriously to perturb the orbits of certain comets which pass very close to his surface—a result which is found not to be the case. But the meteoric theory is only thrown back a step. If the sun's mass were originally formed, as is not at all improbable, by the agglomeration of these particles, Sir William Thompson has calculated that the heat generated by their thus falling together would be sufficient to account for a supply of twenty million years of solar heat at the present rate of emission. And thus though the meteors are not sufficient to maintain the

* It appears probable that it is also, under favorable circumstances, seen after sunset in the form of the zodiacal light.

energy of our system unimpaired, they may yet have been the original storehouse from which all that energy was derived.

The fact, now placed beyond doubt, that the sun's heat is gradually wasting away, naturally leads us to cast a glance into the future. Far, very far, distant the time must be; long before it comes, in all probability, the firmament will have been rolled together as a scroll, and the old heavens and the old earth will have passed away. But if the economy of our system be spared long enough, the day must come when the sun with age has become wan; when the matter of the corona has been all drawn in and used up without avail; when the lavish luxuriance with which he has showered abroad his light and heat has finally exhausted all his stores. He has still power, aided by the resisting medium,* to drag his satellites one by one down upon his surface; and the shock of each successive impact will, for a brief period, give him a fresh tenure of life. When the earth crashes into the sun,† it will supply him with a store of heat for nearly a century, while Jupiter's large mass will extend the period by thirty thousand years. But when the last of the planets is swallowed up, the sun's energies will rapidly die out, and a deep and deathly gloom gather around nature's grave. Looking into the ages of a future eternity, we can see nothing but a cold and burnt-out mass remaining of that glorious orb, which went forth in the morning of time, joyful as a bridegroom from his chamber, and rejoicing as a strong man to run a race.‡

THE COMETS.

In a sort of "debatable territory" between our own solar system and the infinite stellar universe around, we come upon those erratic and anomalous bodies—the comets; some of which have accidentally become permanent attendants upon our sun; others have only paid it a single casual visit in the course of their wanderings through space, and are not likely again to come within the range of its attracting influence; while countless millions are doubtless scattered throughout the realms of the infinite, whose existence will never be revealed to human ken at all. The extraordinary appearance and anomalous character of these meteors, the apparent irregularity of their movements, the suddenness with which they blaze into the firmament, the gigantic trains of light which they throw out as they near the sun, the frightful velocity with which they whirl round that body, and the sudden diminution of their glory as they recede from it, till they seem to be extinguished in the primeval darkness from which they emerged—all these circumstances,

* See the chapter on Laplace's Nebular Hypothesis.

† In the chapter above referred to we have depicted the earth as falling into the sun, still an intensely heated body. But it is scarcely possible to say whether such a catastrophe, should it ever occur, would not find the sun already a comparatively cold mass.

‡ The scope of these pages does not admit of our entering at greater length into the interesting and important subject of recent solar research. Upon this point our readers must of course refer to larger and more systematic works, or to the original papers scattered over various scientific periodicals. A clear and interesting discussion of solar heat will be found at the close of Professor Tyndall's work on Heat; while the invaluable spectroscopic revelations of Kirchoff, Lockyer, Huggins, and others, which have added so vastly to our knowledge, not only of the sun but of other astronomical bodies, will be found well described in Roscoe's Spectrum Analysis and Proctor's work on the sun.

combined with the mystery in which their real nature is shrouded, have caused these knights-errant of astronomy to be regarded at all times with the deepest interest, generally not unmixed with superstitious dread. In fact, for ages they were hailed by the universal consent of all classes of the community in the light of portents. One was believed to have portended the birth of Mithridates, another the assassination of Julius Cæsar, a third the great plague of 1310. One of the most remarkable on record made its appearance at the time of the Saracenic invasion of Christendom. As the hosts of the Crescent swept on in their irresistible course, the comet waxed brighter and brighter, till at last, as the Caliph Mahmoud laid siege to Constantinople, it filled half the sky with its splendor, and hung night after night over the doomed city in the guise of a blazing scimetar. The Pope scarcely knew at first whether to pray to, or to curse it, but adopting the latter course as more congenial to a true Catholic spirit, he fulminated the thunders of the Church against it, and in the same bull excommunicated both Moslems and comet.

Though the superstitious terrors which used to greet the appearance of a comet have now for the most part passed away, yet the mystery which involved them, and which in a great measure gave rise to those terrors, has by no means been altogether dispelled ; for our ideas of the constituent matter of their several parts can scarcely be regarded as more than conjectural. Most of the comets which are visible to the naked eye consist of two separate and well-defined parts—a round nucleus or head, and a long filmy train of light, the "coma" or "hair," from which comets take their name, and which is known in popular parlance as the tail, though this appellation is not altogether a correct one, for, unlike the sheep in the nursery rhyme, comets do not always "carry their tails behind them," but quite as often in front of them. In former times, indeed, the hairy appendage, when worn in front, was called a beard ; but the distinction has now ceased to be drawn, and front-hair and back-hair alike go by the name of tail. The nucleus, or apparently denser portion of the comet, diminishes considerably in size when near the sun ; while the tail, on the other hand, undergoes a most remarkable augmentation, its length sometimes increasing no less than a million of miles in a single hour.

If, as was universally assumed until within the last few years, the tail of a comet be composed of continuous matter, it must unquestionably consist of some extremely rare gaseous substance, incalculably lighter than our own atmosphere. This is inferred from their inappreciably small weight. Though a comet is often many million times larger than the sun, its mass is yet so insignificant that the most delicate tests fail to detect it at all. Many of us must remember also how in the last great comet, that of 1858, the star Arcturus shone with undiminished brilliancy through the thickest part of the tail. The lightest cloud wreath would have concealed it altogether, and yet the filmy texture of the comet, though millions of miles in depth, could hardly dim its lustre. The enormous increase in the size of a comet's tail when near the sun is simply explained, on the gaseous hypothesis, by attributing it to expansion by heat. The great rarity of its mass would render it extremely sensitive to variations of temperature, and account readily enough for its rapid expansion when near the sun, and contraction when receding from it. The nucleus would consist of a material similar to, though somewhat denser than, the tail; and its shrinking at perihelion would probably be due to the conversion of its outer parts into invisible vapor by the action of the solar rays.

But a novel and most ingenious theory, entirely revolutionizing all our former ideas about comets, has been very recently started, and has met with much acceptance among astronomers. When the showers of falling stars in August and November had been discovered to be caused by the passage of the earth through great clusters of meteoric stones, the paths of those clusters about the sun were investigated, and were discovered to be the same as the orbits of two known periodic comets. This extraordinary coincidence appeared too remarkable to be the work of chance, and the bold idea was conceived that these phenomena, apparently so different, might in reality be identical. And on examination, the great *à priori* improbabilities of the hypothesis are seen to disappear in the most wonderful manner, and it is found to afford not only a possible, but a highly probable, theory of the nature and constitution of the cometary bodies. Every comet is supposed to consist of a vast assemblage of distinct solid masses—stones, rocks, and lumps of metal—flying together through space, and rendered visible, in favorable positions, by the sunlight reflected from them. The smallness of their aggregate mass, and the fact of their not eclipsing any heavenly bodies which pass behind them, are as well accounted for by this supposed discontinuity of their material as by assuming them to be gaseous. So are the sudden changes in shape and size of the tail. It will not be visible except when the comet is in such a position as to turn a sort of flat edge toward us, so that we can look at once through a great depth of its mass. For the reflection from each elementary fragment will be so slight, that it will be only when an enormous number are ranged along the same line of vision that their aggregate light will be sufficient to affect the eye. To borrow a felicitous illustration from Professor Tait, we may see the same thing represented in miniature by the flight of a flock of sea-birds. Great numbers of them often fly about, approximately in one place; and if they are at such a distance as not to be discernible singly, they will be equally invisible when their plane has its face turned towards us. But when a sudden sweep brings them into the plane of our vision, so that we get a number of them nearly in one line, they start into sight at once, as a black streak against the face of the sky.

The nucleus is believed, from recent spectroscopic observations, to consist wholly or mainly of incandescent gas. But the explanation of this necessitates no addition to the meteorolite theory. In the head of a comet, where its component fragments are crowded most closely together, there must be very frequent and violent collisions between them; and the heat generated by these impacts will convert them into vapor, just as we know to be the case when they strike our own atmosphere. Unfortunately no large and bright comet, which could be observed in a thoroughly satisfactory manner, has appeared since the invention of the spectroscope. We may hope that the next one which visits our skies will settle the vexed question of the constitution of the tail. The polariscope tells us that it shines by reflected sunlight, but whether partially or wholly it is unable to decide. If there be any self-luminosity, the spectroscope will reveal it at once, and will show also whether it emanates from solid or gaseous matter. And even if the light is found to be all sunlight, there is reason to hope that if the cometary matter be gaseous it will modify the spectrum sufficiently to make us aware of that fact. On the other hand, if the tail consist only of solid particles, the spectrum will be purely and simply an enfeebled solar one, with all its lines absolutely unmodified. Meanwhile the scale of evidence seems to incline in favor of the newer theory. Professor Tait maintains that certain facts which have never been satisfactorily explained on the old hypothesis can be successfully grappled with by the new one.

The paths pursued by the comets are very various indeed. Many of them like the planets, move in ellipses round the sun, some traversing their orbits in three or four years, while others roam so far away that many centuries elapse before they again revisit our neighborhood. A great number, however, only circle once round the sun, and never return to it again. The orbits into which, in accordance with the law of gravitation, they are bent, are so inconceivably long, that before they can reach the farther parts of them they come within the attracting influence of other stars, and are drawn off to pursue new orbits around new centres; and in this way a comet may wander through the universe for countless ages, seeking rest and finding none, till at last some star seizes it with a firmer grasp than the rest, compels it into a smaller orbit, and thus secures it as a perpetual attendant upon itself.

The question has often been asked, whether there is any likelihood of one of these nomadic bodies coming into collision with our own earth, and if this event *did* take place, what its effect would be upon us. On the meteoric theory the answer to this question is a startling one. The earth *does* come into collision with a comet regularly twice every year, and the result is simply a shower of shooting stars, more or less numerous and brilliant, according to the density of the portion of the tail which we encounter. But we must by no means conclude that every such collision would be attended by equally harmless consequences. Fortunately the comets which we encounter are composed of small and widely-scattered fragments. but many will probably consist of far larger masses more densely crowded together. Numbers of meteoric stones are too large to be converted into vapor during their passage through our atmosphere, and reach the ground in a solid but red-hot state. Several of these are on record which weighed more than a hundred pounds, and one which fell in Spain, in 1810, measured thirty inches in length and weighed three-quarters of a ton. An encounter with a comet composed of such masses as this would be a frightful ordeal for the earth to pass through. Its whole surface would be bombarded for some minutes or hours with great lumps of red-hot rock, which would burn and destroy everything upon which they fell. The only chance of the human race surviving such a catastrophe would lie in the fact that astronomers would probably foresee its advent, and warn every one to take refuge in cellars or under bomb-proof casements, from which they would emerge, after the storm was over, to find all around them a mass of blazing ruins.

Nor is even this the worst form which a collision with one of these dangerous bodies might take. An encounter with the head of a comet would be a far more destructive event than a passage through its tail. And such an event, though extremely improbable, is yet a perfectly possible occurrence. Arago estimated the chances against any particular cometary nucleus striking the earth to be about three hundred millions to one; but still these chances, great as they are, must be by no means confounded with certainty; and indeed we find that on more than one occasion such a collision has very nearly happened. The nucleus of the comet of 1832, for instance, would have struck the earth if it had only been a month sooner. The consequences of such a catastrophe are almost too horrible to be contemplated. If, as is now generally believed, the nucleus consists of incandescent gas, we should find ourselves plunged in an instant into a mass of blazing vapor, which would scorch every trace of life off the earth's surface, and, not impossibly, dissipate its solid mass in smoke. If, on the other hand, as several astronomers of note have believed, certain cometary nuclei are composed of one solid mass, the results of a collision would be little less disastrous. Laplace describes them thus: "It is easy to represent the effects of the shock produced by the earth's encountering a comet. The axis and the motion of rotation changed; the waters abandoning their former position to precipitate themselves toward the new equator; a great part of men and animals whelmed in a universal deluge, or destroyed by the violent shock imparted to the terrestrial globe; entire species annihilated; all the monuments of human industry overthrown—such are the disasters which a shock of a comet would necessarily produce." And even if, returning to the old hypothesis, we suppose ourselves coming into contact with a purely gaseous comet, though no mechanical shock of the above nature would be experienced, the chemical consequences might yet be equally fatal. Whatever the cometary material may be, it is not likely that it will be the same as that which composes our own atmospheric air; and, as our lungs are not adapted for the inhalation of any other kind of gas, the probable effect of the intermingling of our atmosphere with the substance of a comet would be at once to render the former utterly unfitted for the support of animal life.

LAPLACE'S NEBULAR HYPOTHESIS.

We have now completed our survey of the great system of which we ourselves form a part. Sun, planets, satellites, and comets—all the elements of the solar system—have successively passed before us; and the only heavenly orbs we have left to consider are the more distant stellar ones, which are so far removed from our own immediate ken. But before we proceed to visit those distant realms, we must glance for a moment at Laplace's great theory of the origin of our system, one of the grandest and most magnificent speculations which it has ever entered into the heart of man to conceive. It is true that Newton's discovery of the law of gravitation furnished us with a key to much that was dark and inexplicable before; it reduced the motions of the planets to harmonious symmetry, and replaced the elaborate eccentrics, cycles, and epicycles of the ancients by simpler and more familiar curves. That law, as all our readers are aware, explains why the planets move in ellipses, and accounts for their different periods and ever-varying velocities; but there are questions which it does *not* answer—such as why all those elliptical orbits are so nearly circular, and why the planets and satellites all revolve round their primaries and rotate on their axes in the same direction—namely, from west to east. On these points Newton's law throws no light; the solar system would be equally possible, and, with certain limitations, equally stable, and equally fitted for the support of life if this remarkable uniformity did not exist. To what, then, are we to attribute it? Is it likely to have been a direct and arbitrary exercise of the Creative will, or a less direct result of that power, working by natural means from some prior form of existence? Were the sun and planets called suddenly into being in their present forms and with their present motions, or were they developed by slow and gradual steps from some simpler original creation? Science tells us that both hypotheses would accord sufficiently well with known present facts; reverential thought pronounces neither of them inconsistent with the loftiest views of the Divine power and wisdom. But the latter is certainly the more interesting and attractive to us, and, we may perhaps add, apparently the more consonant with what we see of the Almighty's working in the lesser world around us. We see the perfect man developed from a helpless babe; we see the loftiest tree developed from a tiny bud; and there is nothing incongruous in supposing that our glorious system itself may have sprung from some vast but equally simple germ. This is a subject which must be handled with humility and diffidence; for we are leaving the regions of mathematics and entering upon those of uncertain speculation; we are treading on sacred grounds in seeking to enter into the counsels of the Great Architect of the Universe. We are endeavoring to go deeper than the laws of nature will take us; we are seeking for a key to the mysteries of our system in the probable circumstances of its creation. For this it is that the bold and lofty speculation of Laplace seeks to do; it reaches back into the unfathomable ages of a past eternity, and takes its stand beside the Almighty Author of all things at the first exercise of his creative fiat, when the foundations of the earth and the heavens were laid, when the morning stars sang together, and all the sons of God shouted for joy.

The Nebular Hypothesis is briefly and poetically summed up as follows by the Poet Laureate in "The Princess":

> "This world was once a fluid haze of light,
> Till toward the centre set the starry tides,
> And eddied into suns, that wheeling cast
> The planets."

Laplace supposes that the first great act of creation—possibly the only one which strictly merits the name, the only one in which things that are seen were made not of things that do appear—was the calling into existence everywhere throughout the infinite regions of space a huge, chaotic, and nebulous mass of matter, such as was supposed to form the substance of the cometary bodies.* This is the only hypothetical step in the whole argument, all the rest following from it, as we shall see, by a course of the most rigid deduction. And against this hypothesis we think no reasonable objection can be urged. It accords with the language of Scripture—"the earth was without form and void, and darkness was upon the face of the deep." It harmonizes with the other sciences; the geologist, in particular, having often to suppose the existence at a former period of a state of things springing from some such origin as this. Nor is it only to the man of science that the idea commends itself; it is a favorite theme with the poets. We find it in the pages of Hesiod, of Ovid, and of Dante. Milton gives it expression thus:

> "A hoary deep, a dark
> Illimitable ocean, without bound,
> Without dimension, where length, breadth and height,
> And time, and place, are lost; where eldest Night
> And chaos, ancestors of Nature, hold
> Eternal anarchy amidst the noise
> Of endless wars, and by confusion stand.
>
> A wild abyss,
> The womb of Nature, and perhaps her grave,
> Of neither sea, nor shore, nor air, nor fire,
> But all these in their pregnant causes mixed
> Confus'dly . . . Chaos umpire sits,
> And by decision more embroils the fray
> By which he reigns: next him, high arbiter,
> Chance governs all."

But the Spirit of God moves upon the face of the waters, and the first elements of order begin to emerge from primeval chaos.

As all the particles of this nebulous mass would exert a mutual attracting influence upon each other, it follows, in accordance with the law of gravitation, that they would begin to settle down and condense gradually around certain centres, the matter at which, from the intestinal workings of the whole, had become denser than the general mass around. And each of the nuclei thus formed contains the embryo of a separate sun; in each void chaotic mass the eye of the philosopher can already detect the germ not only of the great central orb, but of all its gorgeous band of attendants—planets and asteroids, satellites and rings. Let us follow the history of one of these nebulæ—say the parent of our own system—and trace the steps of its gradual elimination from chaos and conversion into the glorious cosmos which we now behold it.

The particles of this mass will all, of course, gravitate toward the centre, and a spherical form will thus be assumed by the whole body; but as the particles will approach the centre from opposite sides and with different velocities, a motion of rotation round an axis will necessarily be generated—slow at first, but rapidly increasing in velocity. As the ball condenses more and more, and shrinks into smaller bulk, it will, by a familiar mechanical law, spin round faster and faster; till at length the centrifugal force at the

* We give in the text Laplace's own theory unaltered. Those who accept the modern hypothesis of the nature of comets would have to replace his "fluid haze of light" by a vast cloud of meteoric stones. But this supposition would not invalidate the theory; it would accord equally well with the rest of Laplace's speculation; and every step in the after development would be the same in either case.

equatorial parts will overbalance the attraction of gravity, and a ring of surface-matter will detach itself from the general mass, and remain poised in mid-air behind as the ball within shrinks farther and farther away from it. The same process will be repeated over and over again, until at last the central mass becomes sufficiently solidified to resist any further separation of its parts. Now if we look at the case of any of these rings, we shall find that the form it eventually assumes will be different in different cases. If its material, as it is detached from the central mass, should happen to be of extremely uniform consistency throughout, and to be poised with extreme accuracy about its centre, it might possibly cool down and solidify in the ring-shape ; * but the chances against this are so great that we should expect it to be a very rare phenomenon indeed. If the density of the ring were at all irregular, it would inevitably split up into fragments, as the cohesion of its parts would be very slight. The largest of these fragments would, by its superior attraction, assume the others into its mass, and the whole would solidify into one globe of considerable size, except in the rare case of all the fragments happening to be about the same magnitude, when they would continue separate, and revolving round their primary in very nearly coincident orbits. Of course the planets, as they were thrown off from the sun, would proceed, in turn, to develop satellites of their own in the same manner and with the same possible varieties.

Now all of these results we find actually occurring in nature. The perfect rings we have in the case of Saturn ; the groups of small planets near together are represented by the asteroids ; while in every other case we meet with the arrangement which we have seen would be the most likely to occur —a large satellite revolving round its primary, and situated at a considerable distance from any of the others. All the peculiarities of planetary motion, too, are accounted for by this theory. The planes in which the planets move are nearly coincident with the plane of the sun's equator, because the matter of which they are composed is thrown off from the tropical parts of that body. Their orbits are nearly circular, because such would be the motion of their particles while yet in the ring condition. And the direction in which they revolve is the same as that in which the sun turns on its axis, because they would acquire an impulse in that direction before they parted company with it.†

The nature and origin of the comets are also easily explained on this hypothesis. When the original nebulous material of the universe began to gravitate toward its several centres, large masses of it seem to have been in many cases left behind, too, evenly balanced between the different attracting

* This part of Laplace's theory must be somewhat modified to render it consonant with the discoveries of modern science. It has been shown that a ring, such as Saturn's, could not possibly exist in a solid state, but that it must be composed of separate fragments or meteorolites such as constitute the matter of the solar corona, and probably of the comets. But the theory readily adapts itself to the explanation of such a phenomenon. The ring would be detached from its primary in a viscous state ; and as it would be impossible for it to solidify as a whole, it would break up into small fragments which would solidify separately and move in nearly coincident orbits, thus preserving the general form of a ring, although not one composed of continuous matter.

† The theory also accounts for the fact of the planets rotating about their axes in the same direction as that of their orbital revolution. When a fragment was detached from the ring, its outer particles would have a greater velocity in the general direction of motion than its inner ones, and there would be on the whole a moment of momentum in that direction about the centre of gravity.

influences to yield to any one of them. But as their position would be one of unstable equilibrium, in the course of time the attraction of some one or other of the centres would come to predominate, and the filmy and uncondensed mass would gradually yield to its sway, and descend toward the controlling orb. Another very mysterious point which the nebular hypothesis accounts for, is the existence of a resisting medium around the sun, and extending to a considerable distance from it. The existence of such a medium is now undoubted. Encke's comet, which possesses the smallest orbit of any connected with our system, is sensibly drawing nearer and nearer to the sun at every revolution; and this fact cannot be accounted for in any other way than by supposing this medium to exist. On Laplace's hypothesis its origin is readily explained; it must evidently be part of the original solar nebula, which, from its extreme rarity, has never undergone condensation at all.* The terrible part which this resisting medium may be destined to play in the great drama of the universe is indicated but too plainly by the effect it has already begun to produce on the comet which comes most immediately under its influence. Slackening by sure though imperceptible degrees the speed of every planet and comet in the system, and thus stealing away their power to resist the sun's attracting force, it will, by its insensible influence, bring them all in time within that orb's resistless grasp, till one by one they drop through his fiery atmosphere and sink to rest upon his surface. Thus, to quote the words of Professor Nichol, one of the warmest advocates of the nebular hypothesis, "The first indefinite germs of the great organization of the universe, provision for its long existence, and finally its shroud, are all involved in that master conception from which Laplace endeavors to survey the mechanisms amid which we are. Not in confusion, however, shall this majestic system finally pass away—not with the jar and confused voice of ruin, but even in its own quiet and majestical order, like the flower which, having adorned a speck of earth, lets drop its leaves when its work is done and falls back obediently on its mother's bosom."

The terms in which the final destruction of our earth is spoken of in Scripture, and the comparatively short existence which seems to be in Providence destined for it, render it pretty certain that this globe at least will not meet with its doom in the above-mentioned manner. But as such an event is not only a perfectly possible one in the economy of nature, but an absolute certainty supposing that the resisting medium were allowed time enough to do its work,† it may not be out of place to pause for a moment and consider what is involved in such a catastrophe. Let us think, for example, what the case would be with our own earth, if no speedier destruction were to come upon it from some yet unanticipated and possibly miraculous cause. Many centuries no doubt—it may be many millenniums—would elapse before the most delicate observations could reveal the working of the mysterious agent. But at length some astronomer detects a minute change in the elements of the earth's orbit which cannot be accounted for by any of the ordinary pertur-

* On the more recent theory, it will probably be simply the matter composing the solar corona.

† The fact of the gradual dissipation of the energy of our system, established by Sir William Thomson, points also to the final destruction of the earth, and would tend to hasten the catastrophe we describe.

bations, and he is compelled to the belief that the resisting medium is beginning perceptibly to influence the planet. This discovery, when publicly announced, could not fail seriously to impress the most thoughtless of hearers. The first step has been taken by the earth on its way to a doom as fearful as the imagination can paint and as inevitable as the unchanging laws of nature can make it. Still generation after generation passes away; the end is—visibly—no nearer, and but for the figures of the astronomers the whole thing might be denounced as an idle fable. But not the less surely does the unseen destroyer fulfil his mission; and in time the effects of his work become palpable to every eye. The sun's disk is perceptibly enlarged, the intensity of his light and heat are increased, the length of the year is diminished. At first the change of climate is a pleasant and grateful one, except beween the tropics, and even there it is not so marked as to be very severely felt. But slowly and surely the influence becomes more potent, and when we look again some ages later, the face of the intertropical regions is scarcely recognizable. The rich vale of the Nile, the fertile plains of the Ganges, the cotton plantations of the South, have disappeared; the sandy deserts of Africa and Asia have extended their bounds and stretch without an oasis far on either side of the equator. The inhabitants retreat, some to the north and some to the south, but the fiery belt between steadily pursues them, and mile after mile, league after league, falls under its devastating sway. Some ages more pass away, and when we look again the vineyards of Spain, the olive-groves of Italy, the fig-gardens of Turkey, are gone; their cities yet stand with all their splendid palaces, their gorgeous temples, but they are like Tadmor in the wilderness—cities without inhabitants. Look again, and Mont Blanc has lost his diadem of snow and rears his head, a bare cone of granite, above the dry and rocky table-land which was once the Mer de Glace. Look again, and our own land has, in its turn, become a burning desert. And now the whole inhabitants of the globe are collected in two narrow circles around either pole. The ice and the snow have disappeared, and the frozen planes of Greenland and Labrador teem with tropical vegetation. But the narrowed limits of the habitable earth can no longer support this vast increase of population, and famine begins to mow down its victims by millions. Now, indeed, the end of all life on the earth draws on apace. The resisting medium, from the increased proximity to the sun, grows rapidly much denser, and its effect is proportionately increased. The heat and drought become more and more insupportable. Rain and dew fall no longer. All springs of water fail, and the rivers dwindle down to streamlets, and trickle slowly over their stony beds. And now scarcity of water is added to scarcity of food. Those who escape from the famine perish by the drought, and those who escape from the drought are reserved for a fate more awful yet. For a time, indeed, the few remaining inhabitants of the earth are partially screened from the overwhelming power of the sun by a dense canopy of clouds. From the excessive evaporation, thick columns of mist are constantly rising from the surface of every lake and every sea, and forming into dense banks of cloud, which hang like a funeral pall over the dying earth. But soon the sun scorches up these vapor-banks and dissipates them into space as fast as they can be formed by evaporation. Then the fiery orb shines out in unutterable splendor without the lightest cloud-wreath to interpose between himself and his victims. Then, truly, the heavens become as iron and the earth as brass. Then the last denizens of the world are stricken down and consumed, the last traces of organic life are blotted from its surface. How different the "last man" here from Campbell's picture of

> "The last of human race,
> Who shall creation's death behold
> As Adam saw its prime!"

Then the last drops of ocean are dried up, and nothing but a bare and blighted mass of rock is left of that earth which once, even in its Maker's eyes, was altogether good. Still the doomed planet rushes on to its awful fate. Swiftly and more swiftly it circles round the sun, like the bark which once drawn within the influence of the whirlpool is sucked irresistibly into its fearful vortex. At last it seems to get paralyzed by the iron grasp that is tightening upon it—it staggers, pauses for a moment in its headlong career, and thus checked in its onward progress the sun draws it straight down to itself. A hurried rush through the tossing sea of fire, a swift plunge through the cloudy stratum behind, and the earth sinks to its eternal resting-place on the face of its parent globe.

THE STARS.

We must turn now to realms lying beyond our own solar system. Beginning with ourselves and our sister planets, we have considered in succession the lesser light which rules the night, the greater light which rules the day, the comets which wing their wild flights around it, and the mysterious ether which encompasses it, and which in time will bring all the rest—planets, satellites, and comets, within its remorseless grasp. And now it remains to wind up by taking a glance at the great stellar universe around us, compared with which our own system, mighty as it is, counts but as a drop in the ocean. And here, as formerly, our subject naturally divides itself into two parts. We have to consider first, those facts relating to the stars which depend upon their general physical character and their individual peculiarities; and secondly, those which depend on their collocation in space and their movements through the realms of the infinite. As for the first, the great distance at which the stars are from us prevents us from knowing almost anything whatever about their condition, except what we can infer from analogy. They hold the same place in creation that our own sun does. They are not satellites of any other body, but primary orbs, independent sources of light and heat, and probably the centres of systems not less varied and gorgeous than our own. Hence we may argue with a high degree of probability that those facts which have been ascertained concerning the general nature of the sun, hold equally true of the stars. And as for their individual peculiarities, we are for the most part equally in the dark about them also, and that for the same reason. All the stars appear to us as mere luminous specks without any perceptible magnitude. And although "one star differeth from another star in glory," though even the naked eye can detect many degrees of brilliancy among them, yet all we can infer from this is that the more brilliant ones are probably much nearer to us than the others. But there are two classes of stars which form marked exceptions to the general rule, and stand out prominently from the rest. These are binary stars, and periodical or temporary stars.

The existence of the binary stars was discovered by Sir William Herschel toward the close of last century. It had long been noticed by astronomers as a remarkable coincidence that in several instances a pair of bright stars were found in very close proximity to each other, much closer than we should have expected supposing the stars to have been scattered up and down at random over the whole face of the heavens. Still it was never thought that this was anything more than a coincidence; it was supposed that the stars had no connection with each other, but were altogether separate bodies, which merely happened to be situated in one straight line with ourselves. But Herschel having, for some scientific purposes which it would take too long to explain, determined to make a series of minute and careful observations upon these double stars, soon found to his surprise that they were rapidly shifting their positions relatively to each other; and, in short, he was erelong led to the conclusion that the two stars were in reality situated close together, and revolving in orbits round one another. Many pairs of stars of this kind were observed and registered, while in some cases the combinations were found to consist of three stars, and even four, instead of two.

But one of the most remarkable features about these multiple stars is that they are very frequently of different colors. In the case of the double stars the two colors are usually complementary; colors, that is, which when mixed together, in proper proportions, produce white. Thus one will be green and the other red, or one orange and the other blue, or one violet and the other yellow. Similarly in the triple stars we may have a blue, a red, and a yellow, or a green, an orange, and a violet. In a quadruple star we may have blue, green, orange, and red; and so on, in endless combinations. If there be any planets in attendance upon these multiple suns, as in all probability there will be, the celestial phenomena at those planets will be of the most extraordinary character indeed, and everything that depends on these phenomena—their times and their seasons, their days and their years —will be involved in the most intricate complications. If indeed any of them happened to be situated in very close proximity to one of the primaries, things with it would not be so confused. It would always revolve round the same sun, though in a very irregular and perturbed orbit; and hence its days and its years would follow each other pretty much in the natural and regular order. But its seasons will vary much both in length and temperature, and its nights, though much darker than its days, will yet differ from them far less than is the case with us. For when the primary orb sinks beneath the horizon, the secondary ones will shine out in full splendor, much smaller and more distant than the primary, but yet far exceeding in brilliancy the borrowed light of the brightest of full moons. But most of the planets, not nestled close enough beside any one of their suns, will come pretty equally under the influence of all. Take for instance the case of a planet in a quadruple system at a time when it happens to be about equally distant from all its four suns. A green and a red sun are above the horizon, and when we look directly at either, its color is clear, brilliant, and well-defined. But their rays meet and mingle and unite into a dazzling snowy white, which imparts to the whole landscape the pure radiant look which seems to fill the firmament on a sunny day when the ground is covered with snow. A light cloud-wreath steals over the green sun, and a faint rosy blush overspreads the face of the sky. The cloud thickens and the rosy hue deepens into a mellow crimson. Then the green sun sets and a blue one rises, changing the red light of the sky into a rich purple, veined here and there with pale amethyst, as a few rays from the green sun struggle through the clouds just as it sinks beneath the horizon. The purple changes into a deep gold as the blue sun is succeeded by an orange one, and the gold pales down as the red sun sinks to his rest in turn. The orange is left alone, and when it, too, sets, night comes on apace. And now the moons rise and shed their radiance on the scene. But how differently do they show from the pale uniform light that beams from our own plain satellite! Every color of the rainbow glows from their faces; in belts, in spots, in lunes, their checkered disks reflect every shade of hue that the artist's palette can produce. The parts illumined by one sun alone reflect, more faintly than the rest, the colors of their respective orbs; those which come within the light of two or three of them will shine more brightly and with gayer combinations of colors; while in the parts on which all the four suns shine at once we find again the snowy white, so bright as to sparkle almost with the light of day. But where there are four great lights to rule the day, night will be of unfrequent occurrence and of short duration; and soon the four suns, their nocturnal course ended, begin at once to draw nigh to their rising. Pale, slender threads of red, green, blue, and orange steal out from the darkness in four quarters of the horizon; and these widen and lengthen till they mingle together at their extremities in softly shading hues of white, indigo, and gold. Brighter and broader they grow, and the gorgeous variegated belt spreads rapidly from horizon to zenith, till at last the suns have fairly risen, and their many-colored rays combine again into the dazzling white of the perfect day.

Nor are the annual phenomena of these planets—those, namely, which are connected with their seasons and their years—less extraordinary than their diurnal phenomena, which relate to their days and nights. Take the case of a planet in circumstances such as we have supposed above, situated at about equal distances from its several suns. It has just returned from performing a revolution about one of them, and while away on the farther side of that body it was pretty far removed from the influence of the others; and hence it has enjoyed a tolerably quiet and orderly year. Its days and its seasons have followed each other in due succession, though in their length and their temperature there were many and varied irregularities. But now completing its circuit, it comes again into the region of confusion and anarchy. New suns wax and brighten till they rival the old one in splendor. Distinction of day and night there is none. Universal summer prevails over the planet—in some places mild, in others extreme—these patches of different climates being seemingly scattered up and down arbitrarily over the face of the globe. But gradually one of the suns—not the same one as before—begins to exercise a markedly more potent influence than the rest; and they slowly dwindle in the distance, while the victorious orb grows larger and brighter as it draws its captive down toward it. And now the planet starts to perform again a new revolution in a comparatively undisturbed orbit. Day and night, summer and winter, seed-time and harvest resume their wonted sway. But how altered are they all! The sun and the moon have changed their size, their brilliancy and their color; new planets stud the sky; new comets wheel around the sun; and only the more distant stars retain their positions unaltered. The year has changed its length; seasons and climate are revolutionized; zones formerly frigid or tropical have become temperate; or those temperate, torrid. The old vegetation, blighted by drought or nipped by unwonted frost, withers away, and new trees and plants take its place. The fauna change with the flora; birds and animals migrate; while whole races of men follow their example, or adapt themselves with difficulty to their altered climates. But scarcely are they settled down to their new circumstances ere a similar change again takes place, and they are whirled off to perform an equally brief circuit around yet another sun. And so on they go in their restless career—

"It may be for years, and it may be forever,"

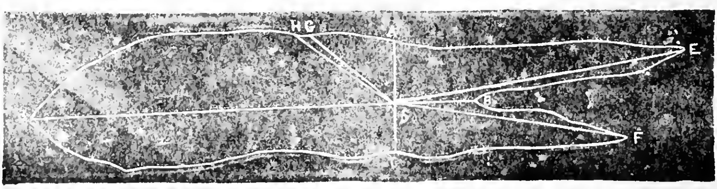
unless a favoring chance carries their planet very near to one of its suns, and thus enables that orb to establish an indisputable sway over it, and secure it as a permanent satellite.

The second class of stars to which we alluded—the periodical and temporary stars—are much rarer phenomena than those which we have just been considering, while their actual nature is altogether unknown to us. There are on record about six or eight instances in which bright stars have suddenly appeared in parts of the heaven where previously there was none, and after continuing to shine with varying brilliancy for a few months or years, have been again utterly extinguished. In one case, at least, it is believed that a star of this kind has reappeared several times at intervals of about one hundred and fifty years—a fact which, if true, would seem to indicate some periodicity in the causes of its appearances and disappearances. In several cases of a somewhat similar kind this periodicity is unquestionably to be found. A good many stars undergo regular increases and diminutions of brilliancy, the period of some being two or three days, of others as many months, and of others several years. Some of them, at stated intervals, disappear for a short time altogether. Various theories have been suggested to account for these phenomena. Some astronomers suppose that the stars in question have large dark planets or companion suns revolving round them, which at intervals interpose between them and us, and cut off the whole or part of their light. Others attribute their varying brilliancy to dark spots and patches upon their surfaces. The temporary stars some suppose to have been altogether annihilated, or to have had their sources of light and heat exhausted. Others suppose them to revolve in very long orbits like the comets, and only to become visible when at the parts of their course nearest to the earth. All these hypotheses are possible, but hypotheses it is to be feared they will ever remain. Nothing but actual observation could tell us which is the correct one, and the bodies in question are so distant that evidence of this kind we can never hope to obtain.

Of the physical constitution of the stars we know but little. Analogy tells us that they are bodies of the same character, and probably of much the same magnitude, as our own sun. Recent spectrum analysis goes further, and shows us from an examination of their light that the substances which exist most plentifully in the sun's atmosphere, such as sodium, are also to be met with largely among the stars. More information about them than this we have not much hope of attaining to. There is no reasonable probability of our ever having telescopes powerful enough to give us further revelations of the nature of the stars. To our present instruments they appear simply as specks of light of no visible dimensions, and differing only in brightness. According to these varying degrees of brilliancy the stars are classed—the brightest being styled of the first magnitude, the next of the second magnitude, and so on through the telescopic stars down to the fifteenth. But this term must not be misunderstood. None of them have any perceptible magnitude whatever; even Sirius, the brightest, presents no marked disk like the planets; he is strictly a mathematical point of light—position without magnitude. It is probable that the stars do not differ very much in actual size and inherent brilliancy, and that their gradations of apparent brightness are due almost entirely to the different distances at which they are situated from us. The tiny orb, which is only revealed to us by the most powerful telescopes, is probably a not less glorious sun than Sirius or Procyon, but it is buried at such a depth in the abysses of space as to be altogether invisible to the unaided eye.

Sir William Herschel was the first astronomer who compared actually the light emanating from the different stars, and calculated from this their probable relative distances. This was done without much difficulty, and he next set himself the great task of discovering from these data the way in which the stars are distributed through space, the configuration of the great stellar universe, and the position which our sun occupies in it. The labor required for this was immense. It involved a careful examination of every part of the sky, both in the northern and southern hemispheres, and a tabling of the number of stars in them arranged in order of magnitude. He patiently directed his telescope by turns to the different quarters of the heavens, and calculated first the number of the larger stars which were to be found in them. The result of this showed that the first three or four magnitudes were distributed about equally over the whole sky; and he accordingly inferred that to a certain distance at least, the stars were grouped uniformly all round us. But then came a sudden break. When he counted those next in order, he found that except in one portion of the sky there were scarcely any; and when he arrived at the telescopic stars—those namely, which are invisible to the naked eye—there were none at all, except in that great luminous belt which spans the whole firmament, and which is known by the name of the Milky Way. The inference from these facts was obvious. In most directions the stars came very speedily to an end, but in one circle all round us they seem to extend almost to infinity. We all know the appearance presented to the naked eye by the Milky Way—a white fleecy background, dotted all over with bright and distinct stars. When the telescope is turned upon it, we get a step further; some of the white background is in its turn resolved into separate stars, but another indistinct layer rises up behind them in turn. Higher and higher telescopic powers were attained, but still with the same result; the astronomer's eye penetrated farther and farther into the depths of space, but still the dim white background of star-dust filled the field of the glass. At length, however, by some optical improvements of Herschel's own devising, he succeeded in considerably increasing the efficiency of his telescopes, and was rewarded by finding the last layer of star-dust completely resolved into distinct and separate orbs. Background there was now none; clear and bright the last stars shone out from the deep black void of the midnight sky. The astronomer laid down his glass; the furthest limits of our universe had been sounded, and its bounds assigned it in every direction. Laying down the telescope, Herschel took up the compasses, and proceeded to map on paper the results of his long and patient search. The conclusion he arrived at was, that the starry universe formed a roundish but irregular disk, with a deep cleft at one side extending nearly down to the sun, which occupies pretty much the centre of the disk. Thus viewed from above or below, the appearance presented would be circular, while laterally it would be that figured in the diagram. *S* is the sun, and if we look in any of the directions *SA*, *SB*, *SC*, the range of stars which we see is a very brief one; but looking along *SD*, or any other direction in a plane through it perpendicular to that of the paper, we have a much farther vista. These directions accordingly correspond to the Milky Way in the heavens. In one part the Milky Way splits up into two branches, separated by a short interval from each other. These two branches are marked in the figure by the lines *SE*, *SF*. The constellations are wedges cut out of this great star-disk. Thus the Great Bear, for example, lies between the lines *SG*, *SH*, and therefore contains no very small stars. The Swan, on the other hand, lies along *SD*, and is hence enriched by a brilliant background of star-dust. Herschel calculated that the number of stars in this enormous cluster is certainly not less than five and a half millions, and is probably one or two millions more.

But a harder problem still remained behind. The relative distances of the stars had been computed, the farthest bounds of the known universe had been pierced, its figure determined, and its limits assigned it in every direc-



tion. But of the absolute dimensions of this great system, astronomers in Herschel's time knew nothing. They had learnt that the farthest stars were about five hundred times more distant from us than the nearest ones. But the distance of even the nearest was a sealed mystery. It was known that it could be measured only by millions of millions of miles; but how many of these great units it contained they could not tell. The way in which the distance of the nearer heavenly bodies is found is very simple. When a land surveyor wishes to ascertain the distance of an inaccessible object, he measures what is called a base-line; and making an observation first from one end of this and then from the other, the displacement in the apparent position of the object gives him its distance from either station. And this is the method pursued with the sun and moon. They are observed simultaneously from two distant points of the earth's surface, and from their consequent displacement—or parallax, as it is called in scientific parlance—their distance is readily found. But no such plan avails us with the fixed stars. The distance of any two stations on the surface of our globe is as nothing compared with the enormous space which separates us from them. But the earth's motion in its orbit comes to our aid, and gives us two standpoints immeasurably farther apart from each other than its own two poles. Let us carefully observe one of the stars now, and then wait till six months have elapsed. The earth's revolution about the sun has brought us to a station two hundred million miles away from that of our first observation. And here surely with such an enormous base-line for our observations the difficulty will be easily solved—the star will appear to have shifted to quite a new part of the heavens. But no—to an ordinary telescope no change whatever is visible. One of the chief arguments of the old astronomers against the Copernican system was founded upon this; if the earth revolved in an orbit of such magnitude, the stars should appear in altogether different positions at different seasons of the year. Copernicus, with a little hesitation, gave the true reply—the stars must be at such a distance from us that our orbit is but as a speck in comparison with it. The astronomers laughed this to scorn; it was impossible to believe that the works of creation should have such vast extent as this explanation would involve. But they were attempting to limit the power of the Almighty. In the eternity of God a thousand years appear as one day; to His infinitude a million million miles are but a single span. Even the distance they thought so impossibly great, we, with the new light of science, know to be but an infinitesimal fraction of the whole dimensions of the universe.

From the days of Copernicus down to the present time, telescopes have steadily been increasing in power and efficiency. Astronomers were well aware that the problem of finding the stellar parallax was only an instrumental difficulty; the stars must suffer some displacement according to the season of the year, and only a sufficiently good telescope in the hands of a sufficiently skilful and accurate observer was required to determine it. By comparing the stellar light with the solar, they had arrived at a rough idea of the probable distance and parallax of some of the stars, and had found reason to think that the paralactic angle was not so small as to make its detection a hopeless task. Several generations of astronomers, however, passed away, and left this, one of the great objects of their life, unfulfilled. The great glory of discovering stellar parallax is shared equally by a Scotch and a Prussian astronomer, Henderson of Edinburgh and Bessel of Königsberg, who made at the same time, about thirty years ago, independent observations of two different stars. The extreme difficulty of the problem will be seen when we state that the displacement found by Bessel, that of a star in the neck of the Swan, is only an angle of a third of a second, or less than a five-thousandth part of the apparent diameter of the sun. We must remember that every astronomical observation is subject to a host of errors. The most perfect telescope ever set up has a score of imperfections in construction and adjustment, and these have to be carefully calculated from repeated observations, and allowed for by difficult mathematical processes. There are also many astronomical sources of error, such as the finite velocity with which light is propagated, and the refraction of its rays by the earth's atmosphere. All these causes produce a far greater displacement in the star than its actual parallax, and the successful elimination of them all, and determination of the small residual angle, is justly regarded as one of the greatest triumphs of human skill and ingenuity. The parallax of these stars having been found, their distances were given at once by a simple trigonometrical formula. The result is that the nearest star is two hundred thousand times farther from the sun than the earth is—in other words, the distance of the sun from its nearest neighbor in the great stellar cluster is twenty millions of millions of miles. It follows that the full dimensions of that great cluster from end to end must be at least twenty thousand billion miles.

One problem more, the last and the loftiest, yet remains to be solved, before we can say that we have completely mastered the system of the universe. We have calculated the dimensions of the great stellar cluster, we have determined its configuration, we have estimated the number of orbs which it contains. The question yet remains whether the stars are really fixed, as their popular name supposes, or whether they, like all the minor bodies we have considered, have their own special orbits and revolutions. Satellites circle round their primaries, planets wheel in obedience to the behest of their parent suns, comets under the same potent spell wing their fiery flight through space. And are there no fixed centres amid all this ceaseless motion, no spots on which the wearied imagination may settle, and contemplate from a solid and stable standpoint the workings of the great mechanism around? Science answers, There is none. Wherever there is matter there must be gravitation. The greatest and most glorious orbs of heaven are not less fully bound by that all-pervading law than the lightest speck of sea-foam or the filmy texture of the comets. The sun himself, upon whose majestic court hundreds of bright attendants wait, is subjected in turn to the influence of his mighty brethren, and rolls at their bidding along his appointed course.

We have seen that the motion of the earth in its orbit causes a displacement in the apparent positions of the stars. This displacement, however, is only a periodical and temporary one; as the seasons circle round, the earth returns to the spot from whence he set out, and the stars resume their old positions. The fact that some of them had a distinct and separate motion, indicating a permanent change of their position relatively to the sun, was first discovered by Edmund Halley. Some observations of the three brilliant stars, Sirius, Arcturus, and Aldebaran, made by the old Egyptian astronomers, had fortunately been handed down to his time, and on looking over them, he perceived that these stars must have shifted their positions since that early time, by a small but well-marked amount. This indicated that either these stars, or the sun, or probably both, must have changed their places by many million miles since those old records were penned by the philosophers of Alexandria. Other astronomers followed in Halley's track, and by the beginning of this century the proper motions of more than a hundred stars had been determined, chiefly by comparing them with Tycho Brahe's catalogue, made out two hundred years before. These proper motions showed great differences in amount and in direction, and no attempt was made to reconcile and systematize them until the subject was taken up by the bold and speculative genius of Sir William Herschel, who revelled in difficulties and whose daring and ambitious spirit always selected the loftiest and apparently most hopeless themes. He succeeded in evoking order out of apparent confusion and chaos, and announced his discovery of the fact, that the sun, with all his gorgeous following, is sweeping majestically through space in the direction of the constellation Hercules. It was not till fifty years afterward that another astronomer was found bold enough to grapple with this mighty theme. It was then taken up by some of the leading astronomers of Russia, with the advantage of half a century's additional observations, and Herschel's results were confirmed in the fullest manner possible. The direction in which the sun is moving is now known beyond the possibility of a doubt. His velocity, however, has been variously estimated at from thirty million to a hundred million miles per annum.

Of course the other suns of our great cluster have their own motions also; their varying position relatively to ourselves depending partly upon our motion and partly on their own. Mathematical theory, proceeding upon Newton's great law, tells us that the centre of this universal motion must be the centre of gravity of the whole stellar cluster; that any star situated there must be at rest, while all the others are circling in ceaseless revolution around it. Mädler, of Dorpat, is the only astronomer who has ventured to seek for this central sun. By studying Herschel's diagram of the stellar system, and combining it with the known direction of our sun's motion, he was led to believe that the centre of gravity of that system must be situated in or near the constellation Taurus. A careful examination of all the stars in that quarter of the heavens made him finally fix upon Alcyone, the central orb of the Pleiades, as being the object of his search. It is probable that his speculations are somewhat premature; the data upon which they are founded are slight and partially uncertain, on account of the extreme slowness of the motions, from which they are deduced. In fact, it is probable that many generations must pass away before a sufficiently long course of observation can either fully confirm or disprove the conclusions at which he arrived. If his theory be correct, the sweet influences of the Pleiades must be potent influences indeed. Holding their eternal court unmoved in the centre of the heavens, they send out their resistless influence to the farthest confines of space, and bend into stately curves around them the most distant bodies of the universe, some of whose grand orbits cannot be traversed in less than five hundred million years.

THE NEBULÆ.

THE astronomer has now completed his investigation of the great stellar system of which our sun forms a member. The figure of that system has been defined, its dimensions calculated, and its motions traced out and analyzed. This was the consummation to which, until very recent periods, astronomers of all ages had been accustomed to look as the great goal to which their science tended, though a goal which even the most sanguine of them scarcely hoped that it would ever actually reach. And now that it has been so fully attained, can the astronomer sit down and rest on his laurels and boast that he has fathomed the remotest depths of the universe of God? Not so. While with slow and toilsome steps he has been creeping up to his first goal, he has at the same time been seeing another gradually emerging from the obscurity in front of him, and now that the former is reached, it is but to see the latter standing clearly out in the distance, more hopelessly inaccessible than the other had ever seemed to be. For when we stand on the remotest orb of the Milky Way the telescope reveals new marvels to our gaze, and opens up fresh and undreamt-of regions for scientific research. Not yet are the wonders of creation exhausted. Had it been so, had these really been the uttermost bounds of God's created works, we should still have pronounced them well worthy in magnificence and grandeur of the Omnipotence which called them into being. Let us think for a moment on what a scale of inconceivable magnitude the universe thus far is built. The orbit of our earth is two hundred million miles in diameter, but so insignificant is this vast distance compared with the great gulf which separates us from the fixed stars, that to all except the very most powerful telescopes those stars seem to occupy exactly the same positions in the sky when viewed from two opposite points of our course.

Try a still farther flight—pass over twenty millions of millions of miles. We have reached the nearest of the stars, and taking our stand on one of its planets, and waiting till evening falls, we look eagerly abroad to mark the altered aspect of the heavens. Here, surely, where we have put such an overwhelming distance between us and our former position, the face of the sky will be no longer recognizable—the old heavens will have passed away from over our head, as well as the old earth from beneath our feet. But no: as the stars one by one steal out from the darkness, they group themselves into their old well-known configurations. There is the Little Bear with its pole-star, and the Great Bear with its pointers; there are the bands of Orion and the sweet influences of the Pleiades; there are Mazzaroth and Arcturus, just as they appeared to Job five thousand years ago, and sixty billion miles away. Vast as is the space we have traversed, it is not a thousandth part of that which separates the two most distant stars of the system, and hence we need not wonder that the change we have found is no greater than that which comes over the distant landscape as the traveller advances a score or two of yards along his way. Let us then pursue our journey still further. Sun after sun beams upon us with its brilliant bandof planets and comets; sun after sun pales and lessens in the distance as we leave it behind in our flight. And gradually a change creeps over the face of the heavens. The general figures of the constellations remain the same, but those behind contract their dimensions and shrink more closely together, while those in front are opening out and growing larger and brighter. At length we near the farthest confines of the Milky Way. Very few and very scattered are the stars which still remain in front of us. We can number them all with ease. And now but three are left before us—but two—but one. That one is reached in turn. We pass to the further side and look forth into the mysterious abyss which lies beyond. Before, behind, to the right, to the left—whichever way we turn our gaze, it meets with naught but the blackness of darkness—the deep gloom of the midnight sky is unbroken by the gleam of a single star. Onward still we wing our daring flight; the last resting-place is abandoned, the last oasis left behind, and we adventure forth into the trackless wastes of space. One by one the planets of this last sun are passed in our course; now and then a comet overtakes us, and blazes swiftly past into the depths beyond; but if we look onward we see that even it soon pauses in its reckless flight, and wheels back on rapid wing to less solitary and untrodden regions. The sun itself dwindles down to a star, and takes its place among a cluster of others which come forth from behind and around it as its paling light permits them to become visible. And soon this cluster too fades, till all distinction of stars in it is lost, and nothing is left but a dim white patch of light, erelong to be blotted out in turn, as it seems to be swallowed up by the surrounding darkness. All created works are left behind, and we stand alone face to face with the infinitude of God—alone where mortal footstep has never trod, where presence there has never been, save that of the ever-omnipresent Creator and the spirits which pass and repass, ascending and descending the ladder of vision which bridges the chasm between heaven and earth, as they go and come, ministering to the heirs of salvation.

But suppose that our vision is now quickened by telescopic aid. We turn the glass in the direction from which we have just come to get a last look of the universe we are leaving behind us. And surely enough the little white patch steals out again from the darkness in the centre of the field of view. But what is that faint film of light that clouds the outer edge of the circle? Turn the full power of the instrument upon it, and it brightens into a white patch exactly similar to the former. Move the telescope round, and another, and another, meets the eye. Direct it to any new quarter of the heavens, and the sight presented is the same. The whole sky is mottled with these flecks of white. Thick they are as the motes that dance in the sunbeam, close as the stars that stud the firmament, innumerable as the grains of sand upon the shore. In aspect they exactly resemble the dim and distant appearance presented to view by the system which we have just left—so exactly, that when once the glass has been turned away from it, we find it impossible, on turning back, to pick it out from the multitudes that surround it. Let us choose out one of the nearest and brightest of these, and wing our flight toward it. As we approach it, we might think that we were but returning to the system we had left. The white patch widens and brightens, stars emerge from it by thousands and tens of thousands, till it fills the whole firmament with a blaze of splendor, surpassing by many fold the brilliancy of our own nocturnal sky. For the telescope teaches us that while each of these objects is a system of stars probably not inferior in glory to that of which we form a part, many of them must surpass it in magnificence at least a thousand-fold.

It would be hopeless to attempt expressing in ordinary language the vast distance at which these clusters of stars are situated from us. If we were to reckon it in miles, or even in millions of miles, figures would pile upon figures, till in their number all definite idea of their value was lost. We must choose another unit to measure these infinitudes of space—a unit compared with which the dimensions of our own solar system shrink into absolute nothingness. The velocity of light is such that it would flash fifteen times from pole to pole of our earth between two beats of the pendulum. It bridges the huge chasm that separates us from the sun in little more than eight minutes. But the light that shows us these faint star-clusters has been travelling with this frightful velocity for more than two million years since it left its distant source. We see them to-day in the fields of our telescopes, not as they are now, but as they were countless ages before the creation of man upon the earth. What they are now, who can tell? Recent spectrum analysis reveals many of them to us as consisting not of separate stars, like their companion nebulæ, but of purely gaseous matter. They appear as vast oceans of flaming gas, doubtless much resembling what we have described as the condition of the solar envelope, but hanging altogether isolated in space, while they spread their huge billows over countless millions of miles. In others we see the work of condensation already begun, as their central parts show traces of solid, or at least of liquid, matter. In fact they realize Laplace's magnificent conception of the original state of our own system—a void chaotic mass, containing in it the germs of all the stars that lighten our midnight sky. But from all this we can argue nothing of their present state. It may well be that their transformation has been effected ages since, and that they too have long ago split up into countless myriads of suns.

And what we were when their light started on its mission toward us, God alone knows. A fiery globe of molten rock—a thin cloud of vapor without form and void—or, it may be, not yet in existence at all, unseen and undreamt of save in the eternal counsels of the Creator. Not till the rays had well nigh completed their flight were the progenitors of those for whose eyes they were destined first formed upon the earth. The six thousand years of man are as nothing compared with their long journey. Two hundred generations have come and gone since Adam walked in Paradise, but if each of these generations had been told over two hundredfold, the antiquity of man would not have rivalled the hoary age of these tiny waves of light. So small are the undulations of ether, that forty thousand of them follow each other within the space of a single inch, so impalpable that they beat upon our eyeballs in countless millions and with incalculable velocity without injuring their delicate surface; and yet so infinitely strong, when guided by their Maker's hand, that they have steered their unerring course for millions of billions of miles, and reached their destination unaltered and unenfeebled.

Of a truth "things small and great," the infinitesimal and the infinite, "bless the Lord; they praise Him and magnify Him forever." What overwhelming force in these words of God when read by the light of His works: "When I consider Thy heavens, the work of Thy fingers, the moon and the stars which Thou hast ordained; what is man that Thou art mindful of him, and the son of man that Thou visitest him?" And what unspeakable preciousness in these: "Thus saith the Lord, the heaven is my throne, and the earth is my footstool; but to this man will I look, even to him that is poor and of a contrite spirit and that trembleth at my word."

And now let us go one step further, and ask ourselves where these magnificent creations, rising above each other in the scale of magnitude and grandeur, are to have an end. First we had planets with their attendant satellites, then suns with their accompanying planets, then a great cluster consisting of many million suns, and now this vast system composed of thousands of similar clusters. How many steps more we might go in this ascending scale before we reached the climax, it is impossible to say. The system of clusters which we have above described may be itself but a unit in a yet greater and more gorgeous whole, and that whole in turn an insignificant fraction of a creation grander yet. But whatever the end may be, to us in our present state it has already come. Farther than we have now reached, our finite powers of observation can never hope to attain. A veil of impenetrable obscurity is drawn over all that lies beyond. The Almighty has interposed His stern fiat before the advancing flood of human science, which would fain overspread all creation with its triumphant billows. "Hitherto shalt thou come, but no further, and here shall thy proud waves be stayed." The glories that lie beyond are among those things which eye hath not seen, which ear hath not heard, and which it hath not entered into the heart of man to conceive. But though we cannot trace the steps in the ascending scale of creation, we may soar past them in imagination, and ask what the great climax will be. God himself is infinite, but His works must be finite. Suns, clusters, and systems may rise above each other in almost endless succession, but at length some one great system must be reached, whose members, circling round and round in harmony among themselves, must include within their vast limits all the works of the Creator. And what is the mighty centre around which all these motions take place, the one fixed spot in the universe about which all else is in rapid and ceaseless revolution? What can be the worthy centre of this magnificence, the glory compared with which all others sink into the shade? There is indeed a glory that excelleth, a glory such that in the apostle's words even "that which was made glorious hath no glory by reason of the glory that excelleth." But this is a glory uncreate, a glory that shines with no borrowed splendor; it is the glory of the Godhead. Men speak much of heaven as consisting in the felt nearness and presence of God, and hence of its being a state rather than a place. But they forget that while God himself is infinite, the human nature of our Lord and Saviour cannot be so, and hence that there must be some one spot dignified above all others by a special Shechinah—a special manifestation of the glory of the Godhead—that spot where the seer of Patmos beheld a throne set in heaven, and One that sat upon the throne, and in the midst of it a Lamb as it had been slain. And if we ask again what can be the fitting centre of all the gorgeous systems which the science of astronomy reveals to our astonished gaze, what answer *shall* we, what answer *can* we, give but one? Surely we must say with the patriarch, "THIS IS NONE OTHER THAN THE HOUSE OF GOD, THIS IS THE GATE OF HEAVEN."

APPENDIX.

THE PAST HISTORY OF OUR MOON.

THE moon, commonly regarded as a mere satellite of the earth, is in truth a planet, the least member of that family of five bodies circling within the asteroidal zone, to which astronomers have given the name of the terrestrial planets. There can be no question that this is the true position of the moon in the solar system. In fact, the fashion of regarding her as a mere attendant of our earth may be looked upon as the last relic of the old astronomy in which our earth figured as the fixed centre of the universe, and the body for whose sake all the celestial orbs were fashioned. In this aspect, also, the moon is a far more interesting object of research than when viewed as belonging to another and an inferior order. We are able to recognize, in her, appearances probably resulting from the relative smallness of her dimensions, and hence to derive probable information as to the condition of other orbs in the solar system which fall below the earth in point of size. Precisely as the study of the giant planets, Jupiter and Saturn, has led astronomers to infer that certain peculiarities must result from vastness of dimensions, so the study of the dwarf planets, Mars, our moon, and Mercury, may indicate the relations we are to associate with inferiority of size.

This thought immediately introduces us to another conception, which causes us to regard with even greater interest the evidence afforded by the moon's present condition. It can scarcely be questioned that the size of any member of the solar system, or rather the quantity of matter in its orb, assigns, so to speak, the duration of that orb's existence, or rather of the various stages of that existence. The smaller body must cool more rapidly than the larger, and hence the various periods during which the former is fit for this or that purpose of planetary life (I speak with purposed vagueness here) are shorter than the corresponding periods in the life of the latter. Thus the sun, viewed in this way, is the youngest member of the solar system, while the tiniest members of the asteroid family, if not the oldest in reality, are the oldest to which the telescope has introduced us. Jupiter and Saturn come next to the sun in youth ; they are still passing through the earliest stages of planetary existence, even if we ought not rather to adopt that theory of their condition which regards them as subordinate suns, helping the central sun to support life on the satellites which circle around them. Uranus and Neptune are in a later stage, and perchance when telescopes have been constructed large enough to study these planets with advantage, we may learn something of that stage, interesting as being intermediate to the stages through which our earth and Venus on the one hand, and the giant brothers Jupiter and Saturn on the other, are at present passing. After our earth and Venus, which are probably at about the same stage of planetary development (though owing to the difference in their position they may not be equally adapted for the support of life), we come to Mars and Mercury, both of which must be regarded as in all probability much more advanced and in a sense more aged than the earth on which we live. In a similar sense—even as an ephemeron is more aged after a few hours of existence than a man after as many years—the small planet which we call "our moon" may be described as in the very decrepitude of planetary existence, nay (some prefer to think), as even absolutely dead, though its lifeless body still continues to advance upon its accustomed orbit, and to obey the law of universal attraction.

Considerations such as these give singular interest to the discussion of the past history of our moon, though they add to the difficulty of interpreting the problems she presents to us. For we have manifestly to differentiate between the effects due to the moon's relative smallness on the one hand, and those due to her great age on the other. If we could believe the moon to be an orb which simply represents the condition to which our earth will one day attain, we could study her peculiarities of appearance with some hope of understanding how they had been brought about, as well as of learning from such study the future history of our own earth. But clearly the moon has had another history than our earth. Her relative smallness has led to relations such as the earth never has presented and never will present. If our earth is, as astronomers and physicists believe, to grow dead and cold, all life perishing from her surface, it is tolerably clear, from what we already know of her history, that the appearance she will present in her decrepitude will be utterly unlike that presented by the moon. Grant that after the lapse of enormous time-intervals the oceans now existing on the earth will be withdrawn beneath her solid crust, and even (which seems incredible) that at a more distant future the atmosphere now surrounding her will have become greatly reduced in quantity, either by similar withdrawal or in any other manner, yet the surface of the earth would present few features of resemblance to that of the moon. Viewed from the distance at which we view the moon, there would be few crateriform mountains indeed compared with those on the moon; those visible would be small by comparison with lunar craters even of medium dimensions; and the radiated regions seen on the moon's surface would have no discernible counterpart on the surface of the earth. The only features of resemblance, under the imagined conditions, would be probably the partially flat sea bottoms (though these would bear a different proportion to the more elevated regions) and the mountain ranges, the only terrestrial features of volcanic disturbance which would be relatively more important than their lunar counterparts.

I do not purpose, however, to discuss the probable future of the earth, having only indicated the differences just touched upon in order to remind the reader at the outset that we have not in "the moon" a representation of the earth at any stage of her history. Other and different relations are presented for our consideration, although it may well be that by carefully discussing them we may learn somewhat respecting our earth, as also respecting the past history and future development of the solar system.

It appears reasonable to regard the moon, after her first formation as a distinct orb, as presenting the same general characteristics that we ascribe to our earth in its primary stage as a planet. In one respect the moon, even at that early stage, may have differed from the earth. I refer to its rotation, the correspondence between which and its revolution may probably have existed from the moon's first formation. But this would not materially have affected the relations with which we have to deal at present. We may apply, then, to the moon the arguments which have been applied to the discussion of the first stages of our earth's history.

Adopting this view, we see that at the first stage of its existence as an independent planet, the moon must have been an intensely heated gaseous globe, glowing with inherent light, and undergoing a process of condensation, "going on at first at the surface only, until by cooling it must have reached the point where the gaseous centre was exchanged for one of combined and liquefied matter." To apply now to the moon at this stage the description which Dr. Sterry Hunt gives of the earth. "Here commences the chemistry of the moon. So long as the gaseous condition of the moon lasted, we may suppose the whole mass to have been homogeneous; but when the temperature became so reduced that the existence of chemical compounds at the centre became possible, those which were most stable at the elevated temperature then prevailing would be first formed. Thus, for example, while compounds of oxygen with mercury, or even with hydrogen, could not exist, oxides of silicon, aluminium, calcium, magnesium, and iron, might be formed and condensed in a liquid form at the centre of the globe. By progressive cooling still other elements would be removed from the gaseous mass, which would form the atmosphere of the non-gaseous nucleus." "The process of condensation and cooling having gone on until those elements which are not volatile in the heat of our ordinary furnaces were condensed into a liquid form, we may here inquire what would be the result on the mass of a further reduction of temperature. It is generally assumed that in the cooling of a liquid globe of mineral matter congelation would commence at the surface, as in the case of water; but water offers an exception to most other liquids, inasmuch as it is denser in the liquid than in the solid form. Hence, ice floats on water, and freezing water becomes covered with a layer of ice which protects the liquid below. Some metals and alloys resemble water in this respect. With regard to most other earthly substances, and notably the various minerals and earthly compounds like those which may be supposed to have made up the mass of the molten globe, the case is entirely different. The numerous and detailed experiments of Charles Deville and those of Delesse, besides the earlier ones of Bischoff, unite in showing that the density of fused rocks is much less than that of the crystalline products resulting from their slow cooling, these being, according to Deville. from one-seventh to one-sixteenth heavier than the fused mass, so that if formed at the surface they would, in obedience to the laws of gravity, tend to sink as soon as formed."

Here it has to be noted that possibly there existed a period (for our earth as well as for the moon) during which, notwithstanding the relations indicated by Dr. Hunt, the exterior portions of the moon were solid while the interior remained liquid. A state of things corresponding to what we recognize as possible in the sun may have existed. For although undoubtedly any liquid matter forming in the sun sinks in obedience to the laws of gravity toward the centre, yet the greater heat which it encounters as it sinks must vaporize it, notwithstanding increasing pressure, so that it can only remain liquid near the region where rapid radiation allows of sufficient cooling to produce liquefaction. And in the same way we may conceive that the solidification taking place at any portion of the surface of the moon's or the earth's liquid globe, owing to rapid radiation of heat thence, although it might be followed immediately by the sinking of the solidified matter, would yet result in the continuance (rather than the existence) of a partially solid crust. For the sinking solid matter, though subjected to an increase of pressure (which, in the case of matter expanding on liquefaction would favor solidification), would nevertheless, owing to the great increase of heat, become liquefied, and, expanding, would no longer be so much denser than the liquid through which it was sinking as to continue to sink rapidly.

Nevertheless it is clear that after a time the heat of the interior parts of the liquid mass would no longer suffice to liquefy the solid matter descending from the surface, and then would commence the process of aggregation at the centre described by Dr. Hunt. The matter forming the solid centre of the earth consists probably of metallic and metalloidal compounds of elements denser than those forming the known portions of the earth's crust. In the case of the moon, whose mean density is very little greater than the mean density of the matter forming the earth's crust, we must assume that the matter forming the solid nucleus at that early stage was relatively less in amount or else that we may attribute part of the difference to the comparatively small force with which lunar gravity operated during various stages of contraction and solidification.

In the case of the moon, as in that of the earth, before the last portions became solidified, there would exist a condition of imperfect liquidity, as conceived by Hopkins, "preventing the sinking of the cooled and heavier particles, and giving rise to a superficial crust, from which solidification would proceed downward. There would thus be inclosed between the inner and outer solid parts a portion of uncongealed matter," which may be supposed to have retained its liquid condition to a late period, and to have been the principal seat of volcanic action, whether existing in isolated reservoirs or subterranean lakes, or whether, as suggested by Scrope, forming a continuous sheet surrounding the solid nucleus.

Thus far we have had to deal with relations more or less involved in doubt. We have few means of forming a satisfactory opinion as to the order of the various changes to which, in the first stages of her existence as a planet, our moon was subject. Nor can we clearly define the nature of those changes. In these matters, as with the corresponding processes in our earth's case, there is much room for variety of opinion.

But few can doubt that, by whatever processes such condition may have been attained, the moon, when her surface began to form itself into its present appearance, consisted of a globe partially molten surrounded by a crust at least partially solidified. Some portions of the actual surface may have remained liquid or viscous later than others, but at length the time must have arrived when the radiating surface was almost wholly solid. It is from this stage that we have to trace the changes which have led to the present condition of the moon's surface.

It can scarcely be questioned that those seismologists are in the right who have maintained in recent times the theory that in the case of a cooling globe, such as the earth or moon at the stage just described, the crust would in the first place contract more quickly than the nucleus, while later the nucleus would contract more quickly than the crust. This amounts, in fact, to little more than the assertion that the process of heat radiation from the surface would be more rapid, and so last a shorter time than the process of conduction, by which in the main the nucleus would part with its heat. The crust would part rapidly with its heat, contracting upon the nucleus; but the very rapidity (relative) of the process, by completing at an early stage the radiation of the greater portion of the heat originally belonging to the crust, would cause the subsequent radiation to be comparatively slow, while the conduction of heat from the nucleus to the crust would take place more rapidly, not only relatively but actually.

Now it is clear that the results accruing during the two stages into which we thus divide the cooling of the lunar globe would be markedly different. During the first stage forces of tension (tangential) would be called to play in the lunar crust; during the later stage the forces would be those of pressure.

Taking the earlier stage, during which the forces would be tensional, let us consider in what way these forces would operate.

At the beginning, when the crust would be comparatively thin, I conceive that the more general result of the rapid contraction of the crust would be the division of the crust into segments, by the formation of numerous fissures due to the lateral contraction of the thin crust. The molten matter in these fissures would film over rapidly, however, and all the time the crust would be growing thicker and thicker, until at length the formation of distinct segments would no longer be possible. The thickening crust, plastic in its lower strata, would now resist more effectively the tangential tensions, and when yielding would yield in a different manner. It was at this stage, in all probability, that processes such as those illustrated by Nasmyth's globe experiments took place, and that from time to time the crust yielded at particular points, which became the centres of systems of radiating fissures. Before proceeding, however, to consider the results of such processes, let it be noted that we have seen reason to believe that among the very earliest lunar formations would be rifts breaking the *ancient* surface of the lunar crust. I distinguish in this way the ancient surface from portions of surface whereof I shall presently have to speak as formed at a later time.

Now let us conceive the somewhat thickened crust contracting upon the partially fluid nucleus. If the crust were tolerably uniform in strength and thickness we should expect to find it yielding (when forced to yield) at many points, distributed somewhat uniformly over its extent. But this would not be the case if—as we might for many reasons expect—the crust were wanting in uniformity. There would be regions where the crust would be more plastic, and so readier to yield to the tangential tensions. Toward such portions of the crust the liquid matter within would tend, because there alone would room exist for it. The down-drawing, or rather indrawing, crust elsewhere would force away the liquid matter beneath, toward such regions of less resistance, which would thus remain at (and be partly forced to) a higher level. At length, however, the increasing tensions thus resulting would have their natural effect; the crust would break open at the middle of the raised region, and in radiating rifts, and the molten matter would find vent through the rifts as well as at the central opening. The matter so extruded, being liquid, would spread, so that—though the radiating nature of the rifts would still be indicated by the position of the extruded matter—there would be no abrupt changes of level. It is clear, also, that so soon as the outlet had been formed the long and slowly sloping sides of the region of elevation would gradually sink, pressing the liquid matter below toward the centre of outlet, whence it would continue to pour out so long as this process of contraction continued. All round the borders of the aperture the crust would be melted and would continue plastic long after the matter which had filled the fissures and flowed out through them had solidified. Thus there would be formed a wide circular orifice which would from the beginning be considerably above the mean level of the moon's surface, because of the manner in which the liquid matter within had been gathered there by the pressure of the surrounding slopes.* Moreover, around the orifice, the matter outflowing as the crust continued to contract would form a raised wall. Until the time came when the liquid nucleus began to contract more rapidly than the crust, the large crateriform orifice would be full to the brim (or nearly so), at all times, with occasional overflows; and as a writer who has recently adopted this theory has remarked, "We should ultimately have a large central lake of lava surrounded by a range of hills, terraced on the outside—the lake filling up the space they inclosed."

The crust might burst in the manner here considered, at several places at

* I have occasion to make some remarks at this stage to avoid possible and (my experience has shown me) not altogether improbable misconception, or even misrepresentation. The theory enunciated above will be regarded by some, who may have read a certain review of my Treatise on the Moon, as totally different from what I have advocated in that work, and, furthermore, as a theory which I have borrowed from the aforesaid review. I should not be particularly concerned if I had occasion to modify views I had formerly expressed, since I apprehend that every active student of science should hope, rather than dread, that as his work proceeds he would form new opinions. But I must point out that earlier in my book I had advocated the theory urged above. After describing the radiations from Tycho and other craters, I proceed as follows in chapter iv.: "It appears to me impossible to refer these phenomena to any general cause but the reaction of the moon's interior overcoming the tension of the crust, and to this degree Nasmyth's theory seems correct; but it appears manifest, also, that the crust cannot have been fractured in the ordinary sense of the word. Since, however, it results from Mallet's investigations that the tension of the crust is called into play in the earlier stages of contraction and its power to resist contraction in the later stages—in other words, since the crust at first contracts faster than the nucleus, and afterward not so fast as the nucleus—we may assume that the radiating systems were formed in so early an era that the crust was plastic. And it seems reasonable to conclude that the outflowing matter would retain its liquid condition long enough (the crust itself being intensely hot) to spread widely—a circumstance which would account at once for the breath of many of the rays, and for the restoration of level to such a degree that no shadows are thrown. It appears probable, also, that not only (which is manifest) were the craters formed later which are seen around and upon the radiations, but that the central crater itself acquired its actual form long after the epoch when the rays were formed."

the same—or nearly the same—time, the range of the radiating fissures, depending on the extent of the underlying lakes of molten matter thus finding their outlet; or there might be a series of outbursts at widely separated intervals of time and at different regions, gradually diminishing in extent as the crust gradually thickened and the molten matter beneath gradually became reduced in relative amount. Probably the latter view should be accepted, since, if we consider the three systems of radiations from Copernicus, Aristarchus, and Kepler, which were manifestly not formed contemporaneously, but in the order in which their central craters have just been named, we see that their dimensions diminished as their date of formation was later. According to this view we should regard the radiating system from Tycho as the oldest of all these formations.

At this very early stage of the moon's history, then, we regard the moon as a somewhat deformed spheroid, the regions whence the radiations extended being the highest parts, and the regions farthest removed from the ray centres being the lowest.* To these lower regions whatever was liquid on the moon's surface would find its way. The down-flowing lava would not be included in this description, as being rather viscous than liquid; but if any water existed at that time it would occupy the depressed regions which at the present time are called Maria or Seas.

It is a question of some interest, and one on which different opinions have been entertained, whether the moon at any stage of its existence had oceans and an atmosphere corresponding in relative extent to those of the earth. It appears to me that, apart from all the other considerations which have been suggested in support of the view that the moon formerly had oceans and an atmosphere, it is exceedingly difficult to imagine how, under any circumstances, a globe so large as the moon could have been formed under conditions not altogether unlike, as we suppose, those under which the earth was formed (having a similar origin, and presumably constructed of the same elements), without having oceans and an atmosphere of considerable extent. The atmosphere would not consist of oxygen and nitrogen only or chiefly, any more than, in all probability, the primeval atmosphere of our own earth was so constituted. We may adopt some such view of the moon's atmosphere —*mutatis mutandis*—as Dr. Sterry Hunt has adopted respecting the ancient atmosphere of the earth. Hunt, it will be remembered, bases his opinion on the former condition of the earth by conceiving an intense heat applied to the earth as now existing, and inferring the chemical results. "To the chemist," he remarks, "it is evident that from such a process applied to our globe would result the oxidation of all carbonaceous matter; the conversion of all carbonates, chlorides, and sulphates into silicates; and the separation of the carbon, chlorine, and sulphur in the form of acid gases; which, with nitrogen, watery vapor, and an excess of oxygen, would form an exceedingly dense atmosphere. The resulting fused mass would contain all the bases as silicates, and would probably nearly resemble in composition certain furnace-slags or basic volcanic glasses. Such we may conceive to have been the nature of the primitive igneous rock, and such the composition of the primeval atmosphere, *which must have been one of very great density.*" All this, with the single exception of the italicized remark, may be applied to the case of the moon. The lunar atmosphere would not probably be dense at that primeval time, even though constituted like the terrestrial atmosphere just described. It would perhaps have been as dense, or nearly so, as our present atmosphere. Accordingly condensation would take place at a temperature

* Where several ray centres are near together, a region directly between two ray centres would be at a level intermediate between that of the ray centres and that of a region centrally placed within a triangle or quadrangle of ray centres; but the latter region might be at a higher level than another very far removed from the part where the ray centres were near together. For instance, the space in the middle of the triangle having Copernicus, Aristarchus, and Kepler at its angles (or more exactly between Millichius and Bessarion) is lower than the surface around Hortensius (between Copernicus and Kepler), but not so low as the Mare Imbrium, far away from the region of ray centres of which Copernicus, Aristarchus, and Kepler are the principal.

not far from the present boiling-point, and the lower levels of the half-cooled crust would be drenched with a heated solution of hydrochloric acid, whose decomposing action would be rapid, though not aided—as in the case of our primeval earth—by an excessively high temperature. "The formation of the chlorides of the various bases and the separation of silica would go on until the affinities of the acid were satisfied." "At a later period the gradual combination of oxygen with sulphurous acid would eliminate this from the atmosphere in the form of sulphuric acid." "Carbonic acid would still be a large constituent of the atmosphere, but thenceforward (that is, after the separation of the compounds of sulphur and chlorine from the air) there would follow the conversion of the complex aluminous silicates, under the influence of carbonic acid and moisture, into a hydrated silicate of alumina or clay, while the separated lime, magnesia, and alkalies would be changed into bicarbonates, and conveyed to the sea in a state of solution."

It seems to me that it is necessary to adopt some such theory as to the former existence of lunar oceans in order to explain some of the appearances presented by the so-called lunar seas. As regards the present absence of water we may adopt the theory of Frankland, that the lunar oceans have withdrawn beneath the crust as room was provided for them by the contraction of the nucleus. I think, indeed, that there are good grounds for looking with favor on the theory of Stanislas Meunier, according to which the oceans surrounding any planet—our own earth or Mars, for example—are gradually withdrawn from the surface to the interior. And in view of the enormous length of the time-intervals required for such a process, we must consider that while the process was going on the lunar atmosphere would not only part completely with the compounds of sulphur, chlorine, and carbon, but would be even still further reduced by chemical processes acting with exceeding slowness, yet effectively in periods so enormous. But without insisting on this consideration, it is manifest that—with very reasonable assumptions as to the density of the lunar atmosphere in its original complex condition—what would remain after the removal of the chief portion by chemical processes, and after the withdrawal of another considerable portion along with the seas beneath the lunar crust, would be so inconsiderable in quantity as to accord satisfactorily with the evidence which demonstrates the exceeding tenuity of any lunar atmosphere at present existing.

These considerations introduce us to the second part of the moon's history—that corresponding to the period when the nucleus was contracting more rapidly than the crust.

One of the first and most obvious effects of this more rapid nuclear contraction would be the lowering of the level of the molten matter, which up to this period had been kept up to, or nearly up to, the lips of the great ringed craters. If the subsidence took place intermittently there would result a terracing of the interior of the ringed elevation, such as we see in many lunar craters. Nor would there be any uniformity of level in the several crater floors thus formed, since the fluid lava would not form parts of a single fluid mass (in which case, of course, the level of the fluid surface would be everywhere the same), but would belong to independent fluid masses. Indeed it may be noticed that the very nature of the case requires us to adopt this view, since no other will account for the variety of level observed in the different lunar crater-floors. If these ceased to be liquid at different times, the independence of the fluid masses is by that very fact established; and if they ceased to be liquid at the same time, they must have been independent, since, if communication had existed between them, they would have shown the uniformity of surface which the laws of hydrostatics requires.*

The next effect which would follow from the gradual retreat of the nucleus

* It is important to notice that we may derive from these considerations an argument as to the condition of the fluid matter now existing beneath the solid crust of the earth.

from the crust (setting aside the withdrawal of lunar seas) would be the formation of corrugations—in other words, of mountain-ranges. Mallet describes the formation of mountain-chains as belonging to the period when "the continually increasing thickness of the crust remained such that it was still as a whole flexible enough, or opposed sufficient resistance of crushing to admit of the uprise of mountain-chains by resolved tangential pressures." Applying this to the case of the moon, I think it is clear that—with her much smaller orb and comparatively rapid rate of cooling—the era of the formation of mountain-chains would be a short one, and that these would therefore form a less important characteristic of her surface than of the earth's. On the other hand, the period of volcanic activity which would follow that of chain-formation would be *relatively* long continued; for regarding this period as beginning when the thickness of the moon's crust had become too great to admit of adjustment by corrugation, the comparatively small pressure to which the whole mass of the moon had been subjected by lunar gravity, while it would on the one hand cause the period to have an earlier commencement (relatively), would on the other leave greater play to the effects of contraction. Thus we can understand why the signs of volcanic action, as distinguished from the action to which mountain ranges are due, should be far more numerous and important on the moon than on the earth.

I do not, however, in this place enter specially into the consideration of the moon's stage of volcanic activity, because already, in the pages of my Treatise on the Moon (Chapter VI.), I have given a full account of that portion of my present subject. I may make a few remarks, however, on the theory respecting lunar craters touched on in my work on "The Moon." I have mentioned the possibility that some among the enormous number of ring-shaped depressions which are seen on the moon's surface may have been the result of meteoric downfalls in long past ages of the moon's history. One or two critics have spoken of this view as though it were too fantastic for serious consideration. Now, though I threw out the opinion merely as a suggestion, distinctly stating that I should not care to maintain it as a theory, and although my own opinion is unfavorable to the supposition that any of the more considerable lunar markings can be explained in the suggested way, yet it is necessary to notice that on the general question whether the moon's surface has been marked or not by meteoric downfalls scarcely any reasonable doubts can be entertained. For, first, we can scarcely question that the moon's surface was for long ages plastic, and though we may not assign to this period nearly so great a length (350 millions of years) as Tyndall—following Bischoff—assigns to the period when our earth's surface was cooling from a temperature of 2000° C. to 200°, yet still it must have lasted millions of years; and, secondly, we cannot doubt that the process of meteoric downfall now going on is not a new thing, but, on the contrary, is rather the final stage of a process which once took place far more actively. Now Professor Newton has estimated, by a fair estimate of observed facts, that each day on the average 400 millions of meteors fall, of all sizes down to the minutest discernible in a telescope, upon the earth's atmosphere, so that on the moon's unprotected globe—with its surface one thirteenth of the earth's—about 30 millions fall each day, even at the present time. Of large meteoric masses only a few hundreds fall each year on the earth, and perhaps about a hundred on the moon; but still, even at the present rate of downfall, millions of large masses *must* have fallen on the moon during the time when her surface was plastic, while *probably* a much larger number—including many much larger masses—must have fallen during that period. Thus, not only without straining probabilities, but by taking only the most probable assumptions as to the past, we have arrived at a result which compels us to believe that the moon's surface has been very much marked by meteoric downfall, while it renders it by no means unlikely that a large proportion of the markings so left would be discernible under telescopic scrutiny.

I would, in conclusion, invite those who have the requisite leisure to a careful study of the distribution of various orders of lunar marking. It would be well if the moon's surface were isographically charted, and the distribution of the seas, mountain-ranges, and craters of different dimensions and character, of rills, radiating streaks, bright and dark regions, and so on, carefully compared *inter se*, with the object of determining whether the different parts of the moon's surface were probably brought to their present condition during earlier or later periods, and of interpreting also the significance of the moon's characteristic peculiarities. In this department of astronomy, as in some others, the effectiveness of well-devised processes of charting has been hitherto overlooked.

ANCIENT BABYLONIAN ASTROGONY.*

It is singular to consider how short a time elapsed, after writings in the arrow-headed or cuneiform letters (the Keilschriften of the Germans) were discovered, before, first, the power of interpreting them was obtained, and secondly, the range of the cuneiform literature (so to speak) was recognized. Not more than ninety years have passed since the first specimens of arrow-headed inscriptions reached Europe. They had been known for a considerable time before this. Indeed, it has been supposed that the Assyrian letters referred to by Herodotus, Thucydides, and Pliny, were in this character. Della Valle and Figueroa, early in the seventeenth century, described inscriptions in arrow-headed letters, and hazarded the idea that they are to be read from left to right. But no very satisfactory evidence was advanced to show whether the inscriptions were to be so read, or from right to left, or, as Chardin suggested, in vertical lines. The celebrated Olaus Gerhard Tychsen, of Rostock, and other German philologists, endeavored to decipher the specimens which reached Europe toward the end of the last century; but their efforts, though ingenious and zealous, were not rewarded with success. In 1801 Dr. Hager advanced the suggestion that the combinations formed by the arrow-heads did not represent letters, but words, if not entire sentences. Lichtenstein, on the other hand, maintained that the letters belonged to an old form of the Arabic or Coptic character; and he succeeded to his own satisfaction in finding various passages from the Koran in the cuneiform inscriptions. Dr. Grotefend was the first to achieve any real success in this line of research. It is said that he was led to take up the subject by a slight dispute with one of his friends, which led to a wager that he would decipher one of the cuneiform inscriptions. The results of his investigations were that cuneiform inscriptions are alphabetical, not hieroglyphical; that the language employed is the basis of most of the Eastern languages; and that it is written from right to left. Since his time, through the labors of Rich, Botta, Rawlinson, Hincks, De Saulcy, Layard, Sayce, George Smith, and others, the collection and interpretation of the arrow-headed inscriptions have been carried out with great success. We find reason to believe that, though the original literature of Babylon was lost, the tablet libraries of Assyria contained copies of most of the writings of the more ancient nation. Among these have been found the now celebrated descriptions of the Creation, the Fall of Man, the Deluge, the Tower of Babel, and other matters found in an abridged and expurgated form in the book of Genesis. It is to that portion of the Babylonian account which relates to the creation of the sun and moon and stars that I wish here to call attention. It is not only curious in itself, but throws light,

* From R. A. Proctor's work, "Pleasant Days in Science."

in my opinion, on questions of considerable interest connected with the views of ancient Eastern nations respecting the heavenly bodies.

It may be well, before considering the passage in question, to consider briefly—though we may not be able definitely to determine—the real antiquity of the Babylonian account.

In Smith's interesting work on the Chaldean account of Genesis, the question whether the Babylonian account preceded the writing of the book of Genesis, or *vice versa*, is not definitely dealt with. Probably this part of his subject was included among the "important comparisons and conclusions with respect to Genesis" which he preferred to avoid, as his "desire was first to obtain the recognition of the evidence without prejudice." It might certainly have interfered to some degree with the unprejudiced recognition of the evidence of the tablets if it had been maintained by him, and still more if he had demonstrated that the Babylonian is the earlier version. For the account in the book of Genesis, coming thus to be regarded as merely an expurgated version of a narrative originally containing much fabulous matter, and not a little that is monstrous and preposterous, would certainly not have been presented to us in quite that aspect in which it had long been regarded by theologians.

But although Mr. Smith states that he placed the various dates as low as he fairly could, considering the evidence—nay, that he "aimed to do this rather than to establish any system of chronology"—there can be no mistake about the relative antiquity which he in reality assigns to the Babylonian inscriptions. He states, indeed, that every copy of the Genesis legends belongs to the reign of Assurbanipal, who reigned over Assyria B. C. 670. But it is "acknowledged on all hands that the tablets are not the originals, but are only copies from earlier texts." The Assyrians acknowledge themselves that this literature was borrowed from Babylonian sources, and of course it is to Babylonia we have to look to ascertain the approximate dates of the original documents. "The difficulty," he proceeds, "is increased by the following considerations: It appears that at an early period in Babylonian history a great literary development took place, and numerous works were produced which embodied the prevailing myths, religion, and science of that day. Written, many of them, in a noble style of poetry on one side, or registering the highest efforts of their science on the other, these texts became the standards for Babylonian literature, and later generations were content to copy these writings instead of making new work for themselves. Clay, the material on which they were written, was everywhere abundant, copies were multiplied, and by the veneration in which they were held these texts fixed and stereotyped the style of Babylonian literature, and the language in which they were written remained the classical style in the country down to the Persian conquest. Thus it happens that texts of Rim-agu, Sargon, and Hammurabi, who were 1000 years before Nebuchadnezzar and Nabonidus, show the same language as the texts of these later kings, there being no sensible difference in style to match the long interval between them"—precisely as a certain devotional style of writing of our own day closely resembles the style of the sixteenth century.

We cannot, then, from the style, determine the age of the original writings from which the Assyrian tablets were copied. But there are certain facts which enable us to form an opinion on this point. Babylonia was conquered about B. C. 1300, by Tugultininip, King of Assyria. For 250 years before that date a foreign race (called by Berosus, Arabs) had ruled in Babylonia. There is no evidence of any of the original Babylonian Genesis tablets being written after the date of Hammurabi, under whom it is supposed that this race obtained dominion in Babylonia. Many scholars, indeed, regard Hammurabi as much more ancient; but none set him later than 1550 B. C.

Now, before the time of Hammurabi several races of kings reigned, their reigns ranging over a period of 500 years. They were called chiefly Kings of Sumir and Akkad—that is, Kings of Upper and Lower Babylonia. It is believed that before this period—ranging, say, from about 2000 B. C. to 1550 B. C. (at least not later, though possibly, and according to many scholars, probably, far earlier)—the two divisions of Babylonia were separate monarchies. Thus, evidence whether any literature was written before or after B. C. 2000, may be found in the presence or absence of mention, or traces, of this division of the Babylonian kingdom. Mr. Smith considers, for example, that two works—the great Chaldean work on astrology, and a legend which he calls "The Exploits of Lubara"—certainly belong to the period preceding B. C. 2000. In the former work, the subject of which specially connects it, as will presently be seen, with the tablet relating to the creation of the heavenly bodies, Akkad is always referred to as a separate state.

Now Mr. Smith finds that the story of the Creation and Fall belongs to the upper or Akkad division of the country. The Izdubar legends, containing the story of the Flood, and what Mr. Smith regards as probably the history of Nimrod, seem to belong to Sumir, the southern division of Babylonia. He considers the Izdubar legends to have been written at least as early as B. C. 2000. The story of the Creation "may not have been committed to writing so early;" but it also is of great antiquity. And these legends "were traditions before they were committed to writing, and were common, in some form, to all the country." Remembering Mr. Smith's expressed intention of setting all dates as late as possible, his endeavor to do this rather than to establish any system of chronology, we cannot misunderstand the real drift of his arguments, or the real significance of his conclusion that the period when the Genesis tablets were originally written extended from B. C. 2000 to B. C. 1550, or roughly synchronized with the period from Abraham to Moses, according to the ordinary chronology of our Bibles. "During this period it appears that traditions of the creation of the universe, and human history down to the time of Nimrod, existed parallel to, and in some points identical with, those given in the book of Genesis."

Thus viewing the matter, we recognize the interest of that passage in the Babylonian Genesis tablets which corresponds with the account in the book of Genesis respecting the creation of the heavenly bodies. We find in it the earliest existent record of the origin of astrological superstitions. It does not express merely the vague belief, which might be variously interpreted, that the sun and moon and stars were specially created (after light had been created, after the firmament had been formed separating the waters above from the waters below, and after the land had been separated from the water) to be for signs and for seasons for the inhabitants of the world—that is, of our earth. It definitely states that those other suns, the stars, were set into constellation figures for man's benefit; the planets and the moon next formed for his use; and the sun set thereafter in the heavens as the chief among the celestial bodies.

It runs thus, so far as the fragments have yet been gathered together:

FIFTH TABLET OF CREATION LEGEND.

1. It was delightful all that was fixed by the great gods.
2. Stars, their appearance [in figures] of animals he arranged,
3. To fix the year through the observation of their constellations,
4. Twelve months (or signs) of stars in three rows he arranged.
5. From the day when the year commences unto the close.
6. He marked the positions of the wandering stars (planets) to shine in their courses,
7. That they may not do injury, and may not trouble any one.
8. The positions of the gods Bel and Hea he fixed with him:
9. And he opened the great gates in the darkness shrouded,
10. The fastenings were strong on the left and right.
11. In its mass (*i.e.* the lower chaos) he made a boiling.
12. The god Uru (the moon) he caused to rise out, the night he overshadowed,
13. To fix it also for the light of the night until the shining of the day,
14. That the month might not be broken, and in its amount be regular.

15. At the beginning of the month, at the rising of the night,
16. His horns are breaking through to shine on the heaven.
17. On the seventh day to a circle he begins to swell,
18. And stretches toward the dawn further.
19. When the god Shamas (the sun) in the horizon of heaven, in the east,
20. . .formed beautifully and. . . . . .
21. . . . . .to the orbit Shamas was perfected
22. . . . . .the dawn Shamas should change
23. . . . . going on its path
24. . . . . .giving judgment
25. . . . . .to tame
26. . . . . .a second time
27. . . . .

Of this tablet Smith remarks that it is a typical specimen of the style of the series, and shows a marked stage in the creation, the appointment of the heavenly orbs running parallel to the biblical account of the fourth day of Creation. It is important to notice its significance in this respect. We can understand now the meaning underlying the words, "God said, Let there be lights in the firmament of the heavens, to divide the day from the night; and let them be for signs and for seasons, and for days and years." The order, indeed, in which the bodies are formed according to the biblical account is inverted. The greater light—the sun—is here first, to rule the day: then the lesser light—the moon—to rule the night. These are the heavenly bodies which in this description rule the day of twenty-four hours. The sun may be regarded also as ruling (according to the ancient view, as according to nature) the seasons and the year. The stars remain as set in the heaven for signs. "He made the stars also." "And God set them"—that is, the sun, moon, and stars—"in the firmament of the heaven to give light upon the earth, and to rule over the day and over the night," and so forth.

No one can doubt, I conceive, that the biblical account is superior to the other, both in a scientific and in a literary sense. It states much less as actually known, and what it does state accords better with the facts known in the writer's day. Then, the Babylonian narrative, though impressive in certain passages, is overloaded with detail. In both accounts we find the heavenly bodies set in the firmament by a special creative act and specially designed for the benefit of man. And in passing I would observe that the discovery of these Babylonian inscriptions, however they may be interpreted, and whether they be regarded as somewhat earlier or somewhat later than the Bible narrative, appears to dispose finally of the fantastic interpretation assigned by Hugh Miller and others to the biblical cosmogony, as corresponding to a series of visions in which the varying aspects of the world were presented. It has long seemed to me an utterly untenable proposition that a narrative seemingly intended to describe definitely a certain series of events should, after being for ages so interpreted, require now for its correct interpretation to be regarded as an account of a series of visions. If the explanation were reconcilable in any way with the words of Genesis, there yet seems something of profanity in imagining that men's minds had thus been played with by a narrative purporting to be of one sort yet in reality of quite a different character. But whatever possibility there may be (and it can be but the barest possibility) that the Genesis narrative admits of the vision interpretation, no one can reasonably attempt to extend that interpretation to the Babylonian account. So that either a narrative from which the Genesis account was presumably derived was certainly intended to describe a series of events, or else a narrative very nearly as early as the Genesis account, and presumably derived from it at a time when its true meaning must have been known, presents the sun, moon, and stars as objects expressly created and set in the sky after the earth had been formed, and for the special benefit of man, as yet uncreated.

I am not concerned, however, either to dwell upon this point, or to insist on any of its consequences. Let us return to the consideration of the Babylonian narrative as it stands.

We find twelve constellations or signs of the zodiac are mentioned as set to fix the year. I am inclined to consider that the preceding words, "stars, their appearance in figures of animals he arranged," relate specially to the stars of the zodiac. The inventor of this astrogony probably regarded the stars as originally scattered in an irregular manner over the heavens—rather as chaotic material from which constellations might be formed, than as objects separately and expressly created. Then they were taken and formed into figures of animals, set in such a way as to fix the year through the observation of these constellations. It is hardly necessary, perhaps, to remind the reader that the word zodiac is derived from a Greek word signifying an animal, the original name of the zone being the zodiacal way, or the pathway of the animals. Our older navigators called it the Bestiary.* "Twelve months or signs in three rows." Smith takes the three rows to mean (i.) the zodiacal signs, (ii.) the constellations north of the zodiac, and (iii.) the constellations south of the zodiac. But this does not agree with the words "twelve signs in three rows." Possibly the reference is to three circles, two bounding the zodiac on the north and south respectively, the third central, the ecliptic, or track of the sun; or the two tropics and the equator may have been signified. Instead of "twelve signs in three rows," we should, probably, read "twelve signs along a triple band." The description was written long after astronomical temples were first erected, and as the designer of a zodiacal dome like that (far more recently) erected at Denderah would set the twelve zodiacal signs along a band formed by three parallel circles, marking its central line and its northern and southern limits, so we can understand the writer of the tablet presenting the celestial architect as working in the same lines, on a grander scale; setting the twelve zodiacal signs on the corresponding triple band in the heavens themselves.

The next point to be noticed in the Babylonian astrology is the reference to "wandering stars." Mr. Smith remarks that the word *nibir*, thus translated, "is not the usual word for planet, and there is a star called *Nibir* near the place where the sun crossed the boundary between the old and new years, and this star was one of twelve supposed to be favorable to Babylonia." "It is evident," he proceeds, "from the opening of the inscription on the first tablet of the Chaldean astrology and astronomy, that the functions of the stars were, according to the Babylonians, to act not only as regulators of the seasons and the year, but also to be used as signs, as in Genesis 1 : 14; for in those ages it was generally believed that the heavenly bodies gave, by their appearance and positions, signs of events which were coming on the earth." The two verses relating to Nibir seem to correspond to no other celestial bodies but planets (unless, perhaps, to comets). If we regard nibir as signifying any fixed star, we can find no significance in the marking of the course of the star Nibir, that it may do no injury and may not trouble any one. Moreover, as the fixed stars, the sun, and the moon are separately described, it seems unlikely that the planets would be left unnoticed. In the biblical narrative the reference to the celestial bodies is so short that we can understand the planets being included in the words. "He made the stars also." But in an account so full of detail as that presented in the Babylonian tablet, the omission of the planets would be very remarkable. It is also worthy of notice that in Polyhistor's Babylonian traditions, recorded by

* The following passage from Admiral Smyth's Bedford catalogue is worth noticing in this connection: "We find that both the Chinese and the Japanese had a zodiac consisting of animals, as *zodiacs* needs must, among which they placed a tiger, a peacock, a cat, an alligator, a duck, an ape, a hog, a rat, and what not. Animals also formed the *via solis* of the Kirghis, the Mongols, the Persians, the Mantshus, and the ancient Turks; and the Spanish monks in the army of Cortes found that the Mexicans had a zodiac with strange creatures in the departments. Such a striking similitude is assuredly indicative of a common origin, since the coincidences are too exact in most instances to be the effect of chance: but where this origin is to be fixed has been the subject of interminable discussions, and learning, ignorance, sagacity, and prejudice have long been in battle array against each other. Diodorus Siculus considers it to be Babylonian, but Bishop Warburton, somewhat dogmatically tells us, 'Brute worship gave rise to the Egyptian asterisms prior to the time of Moses.'" There is now, of course, very little reason for questioning that Egyptian astronomy was borrowed from Babylon.

Berosus, we read that "Belus formed the stars, the sun, the moon, and the five planets."

In the tablet narrative the creator of the heavenly bodies is supposed to be Anu, god of the heavens. This is inferred by Mr. Smith from the fact "that the God who created the stars, fixed places or habitations for Bel and Hea with himself in the heavens." For according to the Babylonian theogony, the three gods Anu, Bel, and Hea share between them the divisions of the face of the sky.

The account of the creation of the moon is perhaps the most interesting part of the narrative. We see that, according to the Babylonian philosophy, the earth is regarded as formed from the waters and resting after its creation above a vast abyss of chaotic water. We find traces of this old hypothesis in several biblical passages, as, for instance, in the words of the Second Commandment, "the heaven above, the earth beneath, and the waters under the earth;" and again in Proverbs 30 : 4, "Who hath bound the waters in garment? who hath established all the ends of the earth?" "The great gates in the darkness shrouded, the fastenings strong on the left and right," in the Babylonian account, refer to the inclosure of the great infernal lake, so that the waters under the earth might not overwhelm the world. It is from out the dark ocean beneath the earth that the god Anu calls the moon into being. He opens the mighty gates shrouded in the nether darkness, and creates a vast whirlpool in the gloomy ocean; then "at his bidding, from the turmoil around the moonlike a giant bubble, and passing through the open gates mounted on its destined way across the vaults of heaven." It is strange to reflect that in quite recent times, at least 4,000 years after the Babylonian tablet was written, and who shall tell how many years after the tradition was first invented?—a theory of the moon's origin not unlike the Babylonian hypothesis has been advanced, despite overwhelming dynamical objections; and a modern paradoxist has even pointed to the spot beneath the ocean where a sudden increase of depth indicates that matter was suddenly extruded long ago, and driven forcibly away from the earth to the orbit along which that expelled mass—our moon—is now travelling.

It would have been interesting to have known how the Babylonian tablet described the creation of Shamas, the sun; though, so far as can be judged from the fragments above quoted, there was not the same fulness of detail in this part of the description as in that relating to the moon. Mr. Smith infers that the Babylonians considered the moon the more important body, unlike the writer or compiler of the book of Genesis, who describes the sun as the greater light. It does not seem to follow very clearly, however, from the tablet record, that the sun was considered inferior to the moon in importance, and certainly we cannot imagine that the Babylonians considered the moon a greater light. The creation of the stars precedes that of the moon, though manifestly the moon was judged to be more important than the stars. Not improbably, therefore, the sun, though following the moon in order of creation, was regarded as the more important orb of the two. In fact, in the Babylonian as in the (so-called) Mosaic legend of Creation, the more important members of a series of created bodies are, in some cases, created last—man last of all orders of animated beings, for instance.

If we turn now from the consideration of the Babylonian tradition of the creation of the heavenly bodies to note how the biblical account differs from it, not only or chiefly in details, but in general character, we seem to recognize in the latter a determination to detach from the celestial orbs the individuality, so to speak, which the older tradition had given to them. The account in Genesis is not only simpler, and, in a literary sense, more effective, but it is in another sense purified. The celestial bodies do not appear in it as celestial beings. The Babylonian legend is followed only so far as it can be followed consistently with the avoidance of all that might tempt to the worship of the sun, moon, and stars. The writer of the book of Genesis, whether Moses or not, seems certainly to have shared the views of Moses as to the Sabeanism of the nation from which the children of Abraham had separated. Moses warned the Israelite: "Take good heed unto thyself, lest thou lift up thine eyes unto heaven: and when thou seest the sun, and the moon, and the stars, even all the host of heaven, shouldst be driven to worship them, and serve them, which the Lord thy God hath divided unto all nations under the whole heaven." So the writer of Genesis is careful to remove from the tradition which he follows all that might suggest the individual power and influence of the heavenly bodies. The stars are to be for signs, but we read nothing of the power of the wandering stars "to do injury or trouble any one." (That is, not in the book of Genesis. In the song of Deborah we find, though perhaps only in a poetic fashion, the old influences assigned to the planets, when the singer says that the "stars in their courses fought against Sisera." Deborah, however, was a woman, and women have always been loath and late to give up ancient superstitions.) Again, the sun and the moon in Genesis are the greater and the lesser lights, not, as in the Babylonian narrative, the god Shamas and the god Uru.

We may find a parallel to this treatment of the Babylonian myth in the treatment by Moses of the observance of the Sabbath, a day of rest which the Babylonian tablets show to have had, as for other reasons had been before suspected, an astrological significance. The Jewish lawgiver does not do away with the observance; in fact, he was probably powerless to do away with it. At any rate, he suffers the observance to remain, precisely as the writer of the book of Genesis retains the Babylonian tradition of the creation of the celestial bodies. But he is careful to expurgate the Chaldean observance, just as the writer of Genesis is careful to expurgate the Babylonian tradition. The week as a period is no longer associated with astrological superstitions, nor the Sabbath rest enjoined as a fetish. Both ideas are directly associated with the monotheistic principle which primarily led to the separation of the family of Abraham from the rest of the Chaldean race. In Babylonia the method of associating the names of the sun, moon, and stars with the days, doubtless had its origin. Saturn was the Sabbath star, as it is still called (Sabbatai) in the Talmud. But, as Professor Tischendorf told Humboldt, in answer to a question specially addressed to him on the subject, "there is an entire absence in both the Old and New Testaments, of any traces of names of week-days taken from the planets." The lunar festivals, again, though unquestionably Sabaistic in their origin, were apparently too thoroughly established to be discarded by Moses; nay, he was even obliged to permit the continuance of many observances which suspiciously resembled the old offerings of sacrifice to the moon as a deity. He had also to continue the sacrifice of the passover, the origin of which was unmistakably astronomical—corresponding in time to the sun's passage across the equator, or rather to the first lunar month following and including that event. But he carefully disassociates both the lunar and the luni solar sacrifices from their primary Sabbaistic significance. In fact, the history of early Hebrew legislation, so far as it related to religion, is the history of a struggle on the part of the lawgivers and the leaders of opinion against the tendency of the people to revert to the idolatrous worship of their ancestors and of races closely akin to them—especially against the tendency to the worship of the sun and moon and all the host of heaven.

In the very fact, however, that this contest was maintained, while yet the Hebrew cosmogony, and in particular the Hebrew astrogony, contains indubitable evidence of its origin in the poetical myths of older Babylonia, we find one of the strongest proofs of the influence which the literature of Babylon, when at the fulness of its development, exerted upon surrounding nations. This influence is not more clearly shown even by the fact that nearly 2,000 years after the decay of Babylonian literature, science, and art, a nation like the Assyrians, engaged in establishing empire rather than in literary and scientific pursuits, should have been at the pains to obtain copies of many thousands of the tablet records which formed the libraries of older Babylonia. In both circumstances we find good reason for hoping that careful search among Assyrian and Babylonian ruins may not only be rewarded by the discovery of many other portions of the later Assyrian library (which was also in some sense a museum), but that other and earlier copies of the original Babylonian records may be obtained. For it seems unlikely that works so valuable as to be thought worth recopying after 1,500 or 2,000 years, in Assyria, had not been more than once copied during the interval in Babylonia. "Search in Babylonia," says Mr. Smith, "would no doubt yield earlier copies of all these works, but that search has not yet been instituted, and for the present we have to be contented with our Assyrian copies. Looking, however, at the world-wide interest of the subjects, and at the important evidence which perfect copies of these works would undoubtedly give, there can be no doubt," Mr. Smith adds, "that the subject of further search and discovery will not slumber, and that all as yet known will one day be superseded by newer texts and fuller and more perfect light."