4. The order of the atomic numbers is the same as that of the atomic weights, except where the latter disagrees with the order of the chemical properties.

5. Known elements correspond with all the numbers between 13 and 79 except three. There are here three possible elements still undiscovered.

6. The frequency of any line in the X-ray spectrum is approximately proportional to $A(N-b)^2$, where A and b are constants.

Apart from (2), the conclusions drawn in Moseley's paper are a straightforward interpretation of the experimental facts and involve no theoretical assumption as to the nature of radiation or the structure of the atom.

Moseley's identification of the atomic number as a measure of the nuclear charge afforded an interpretation of the frequency law he had found in accord with Bohr's quantum theory of spectra, which had been published previously. The correctness of this identification has since been verified by Chadwick by direct measurement of the scattering of α rays by the nucleus.

As a result of these brilliant experiments of Moseley, a relation of unexpected simplicity is seen to hold for all the elements. The properties of an atom are defined by a whole number which represents the ordinal or atomic number of the element and, at the same time, its nuclear charge and the number of electrons external to the nucleus. The atomic weight turns out to be in a sense a secondary property and the periodic law of the elements is put on a wider and more philosophical basis by the substitution of the atomic number or nuclear charge for the atomic weight of the atom.

The work of Moseley has formed a solid and indispensable foundation for the subsequent attack by an army of researchers of the great problem of the constitution of the outer atom. His frequency law has proved an invaluable aid in interpreting the intricacies of X-ray spectra and their relation with atomic constitutions—a subject on which so much fine work has been done in recent years.

We have seen that Moseley showed that all possible elements, disregarding isotopes, had been discovered up to number 79 except three,[2] numbers 43, 61, and 75, and he stated "as the X-ray spectra of these elements can be confidently predicted, they should not be difficult to find." The study of the X-ray spectra affords a powerful and unique method of chemical analysis of a mixture of elements; subsequent research has shown that the presence of an element can be detected with certainty and its amount estimated by its X-ray spectrum even if it be present only to the extent of one part in a thousand. The first of these missing elements found by this method, namely, number 72, was called hafnium by Hevesy and Coster. In this case the method of X-ray analysis was all-important since hafnium is always found with zirconium, with which it is chemically so closely allied that separation is very difficult.

If the other missing elements existed in appreciable amount in minerals, their detection seemed certain. A few weeks ago it was announced by Dr. Noddack and Fräulein Tacke that the missing elements 43 and 75 had been identified by their X-ray spectra in material separated from certain platinum minerals. A preliminary account of their investigations has been given in this journal of July 11. One element, 61, in the rare earths remains unidentified; but for this, Moseley's list of numbers is complete from 1 to 84.

Moseley had the spirit and courage of the true pioneer in science, coupled with great original ability and powers of work. It is rare in the history of science that so young a man has achieved so much.

[2] In making this statement, Moseley assumed that number 72 had already been filled by a rare earth element celtium. As we now know, number 72 had not been isolated at the time Moseley wrote. There were not three but four gaps.

Concerning the Rate of Man's Evolution.[1]

By Sir ARTHUR KEITH, F.R.S.

BEFORE proceeding to discuss my subject—"The Rate of Man's Evolution"—it may be well to ask the question: Is evolution at work in England to-day? Are the Londoners of to-day taller than those of two, ten, or twenty centuries ago? Any one who sets out to answer this simple question is brought face to face with the difficulties which encompass the inquiries of the student of man's evolution. His difficulties are those of variability. The men and women we meet on the streets are of varying height; to strike a true average for the stature of Londoners we must measure hundreds of individuals in every district of this great city. Nor would our average for London hold for the men and women of Birmingham, Manchester and Newcastle, nor would the averages for these cities hold for their surrounding districts. To know the average stature of men and women now living in England entails the measurement of many thousand individuals.

Until the War we believed that the average Englishman stood 5 ft. 8 in. in height; figures gathered then compel us to reduce our estimate by nearly 2 in. When we search the ancient graveyards and burial-places of England to ascertain the average stature of the men and women buried in them, our difficulties are even greater. The people buried in ancient tombs differed in height just as much as we do; the numbers available for measurement are limited; we have to estimate stature from the length of their limb bones. If we are uncertain of our modern stature, we are still less certain of that of former times. Still, if for the moment we dispense with the precision of the biometrician, we may say that there has been no great change in the stature of the inhabitants of these islands since the close of the Ice Age, some 12,000 years ago. There have been "ups and downs," but the mean for modern Englishmen of 5 ft. 6 in. may be taken as the pivot on which the scales of stature have been balanced for thousands of years.

When we apply measurement to the size and form of head, and compare the dimensions of modern Englishmen with those of former times, we are again confronted with the perplexities of variability. In the third millennium B.C. the skulls of England were long and narrow. About the beginning of the second millennium the eastern and southern parts were settled by a people with short and wide skulls; in the first millennium,

[1] Discourse delivered at the Royal Institution on Friday, March 6.

probably as a result of a new influx, the long and narrow skull again asserted itself. In Roman times, and more particularly in Saxon times, the long and narrow skull prevailed. Measurements made on living Englishmen lead to the belief that the head-form has changed and is changing—becoming slightly shorter and slightly wider. There is evidence of a similar change in the head-form of the people in Egypt. So far as concerns the brain-capacity of the skull there is no evidence of increase. From the limited data at our disposal we must infer that the people who occupied western Europe at the close of the Ice Age stood distinctly above their successors of to-day in the matter of brain-size.

I have said that in certain details of bodily structure the Egyptians of to-day do differ from the men who built the great pyramids some 5000 years ago. This, however, is not the accepted opinion. Those who maintain that modern man has ceased to evolve cite the similarity between modern and ancient Egyptians to prove their contention. Only ten years ago I was of opinion that the evidence from England led to the same conclusion. My opinion was altered by certain investigations I carried out in 1914–15. I took fifty skulls (twenty-five of men and twenty-five of women) from English graves which were known to be 1000 years old or more; some of them were as ancient as the pyramids. I instituted a minute comparison between these ancient skulls and those of corresponding numbers of men and women who had lived in England during the eighteenth and nineteenth centuries.

The result of this comparison was to convince me that evolution is now at work on our bodies. The chief change is to be seen in the size and shape of the palate; the roof of the mouth tends to become reduced in size and to become narrower. The bony entrance to the nose shows alterations. It tends to become narrower and its lower margin to rise up so as to form a sharp bony sill. The jaws recede and the bony framework of the nose becomes more prominent. The sockets for the eyes become changed in form; the lower margin or sill of the orbit tends to sink downwards in the face, thus increasing the distance between the lower and upper margins of the orbit. At the same time the orbits become narrower from side to side; the breadth across the upper part of the face becomes less. The cheek bones lose their prominence, and there is a tendency for the face to grow narrower and longer.

It may be said that the changes I have described are due to a diminished use of the jaws in modern people, for the jaws form a large and intrinsic part of the face, and any reduction in size and strength in jaws must necessarily alter the whole face. I do not think we can accept a diminished use of the jaws as a true explanation, for this reason. The changes which I have described are confined to about 30 per cent. of the modern population; 70 per cent. show no such change, and yet all live on approximately the same dietary. The cause lies deeper than a mere disuse of jaws; certain stocks and families show these changes to a more marked degree and more frequently than do other stocks and families. Such evidence as I have gathered points to an increasing frequency of these new characters during recent centuries. Apparently evolution makes its conquests in the way just described; progress is made by climbing the scale of percentages.

The result of this investigation took me rather by surprise, for I had been of opinion that men of our type had lived in England for a hundred thousand years or more and retained their essential characters almost unchanged. This belief was founded on a famous discovery made at Galley Hill in 1888. The schoolhouse of Galley Hill occupies a bluff on the southern bank of the Thames, half-way between Dartford and Gravesend. Standing by the schoolhouse we look northwards across the valley to the flat lands of Essex; Tilbury docks, the scene of another famous discovery of ancient human remains, is clearly visible on the far bank of the river. The bluff on which the schoolhouse stands rises 100 feet above the level of the river; between the bluff and the river lies a stretch of marsh fully a mile wide. On the bluff, close by the schoolhouse, is a pit, dug by cement-workers, now disused, but a busy place in 1888. The workmen had exposed a series of beds, consisting of gravel, sand and loam, which extended downwards fully 10 feet below the surface soil. In the lowest bed but one the workmen began to expose parts of a human skeleton; it lay 8 feet below the original surface. At the same level large primitive flint implements had frequently been found. Was the skeleton thus discovered the remains of one who had helped to fabricate these instruments?

Over the skeleton the original beds were seen to be intact; if there had been a burial, these beds should have shown definite signs of having been broken. The workmen and two other observers, who examined the section while some of the bones were still untouched, were convinced that the skeleton had become naturally entombed when the beds of sand and gravel were being formed. As to the man thus brought to light there can be no doubt. I have spent many hours in examining his bones. His skull, jaws and limb bones are marked by certain primitive features, but every one of these can be matched in the skeletons of men who are living in England to-day or have lived in recent times. Galley Hill man was of the modern European type.[2]

Try as I could I did not see how the geological evidence at Galley Hill could be set aside, and I accepted the inevitable conclusion that Galley Hill man was as old as the strata in which he lay. How old are these strata? They are records of the ancient history of the Thames valley. The river made the valley and wrote its records. The gravel deposits on the bluff at Galley Hill are but a fragment of the terraces which fringe both sides of the valley of the Thames at the 100 feet level. These fringing terraces were laid down in the bed of the river or on the shores of its estuary. They tell of a time when the land on which the older and richer parts of Westminster and London now stand lay fathoms beneath the waters of the estuary, and buried deeply by the deposits which accumulated as tides flowed and ebbed.

Geologists recognise other and later terraces of the Thames valley. There is an extensive series at the 50 feet level: Piccadilly runs along this terrace; the foundations of the Royal Institution penetrate its sands, gravels and loams. There are still later deposits of the 25 feet terrace. The Admiralty Buildings, the Houses of Parliament and the Horse Guards stand on this

[2] The circumstances of this discovery and the characters of the skeleton are discussed in my "Antiquity of Man," second edition, 1925.

terrace. We find in this terrace deposits which mark the close of the Ice Age in England, a date which geologists regard as about 10,000 or 12,000 years distance from us. It is clear, then, that much has happened in the valley of the Thames since the river began to lay down the deposits which make up the 100 feet terrace. If geologists did think in terms of years, there are few who would limit the history of this period of the Thames valley to a term of 100,000 years; many, I am sure, would demand twice this sum. If Galley Hill man is as old as the deposit in which his bones lie, then the rate of man's evolution has been so slow as to be almost imperceptible.

In recent years a new light has been thrown on the history of the Thames valley by a simple discovery. Women know that every hat and coat is dated by its cut or design; they believe that fashion began her imperious sway in modern times. Archæologists and geologists groping amongst the dust heaps of the past have found that mankind has always been the slave of fashion. At all times man has shaped his implements according to the prevailing fashion of the place and period. His handiwork is just as datable as are our hats and houses. French archæologists, when they began to explore their caves methodically some sixty years ago, made this discovery; they began to work out the sequence of fashions. It was soon found that the system discovered in caves could be applied to the deposits or terraces of river valleys. The fashions of the river valleys went a long way further into the past than did those of the caves. The deposits of the 100 feet terrace of the Thames valley, for example, were found to contain fashions of three consecutive periods. For the deepest and oldest bed of all implements were worked in a pre-Chellean manner; in the strata just over the burial bed of Galley Hill man implements were of full Chellean workmanship; in the more superficial strata they were worked in the Acheulean manner. Thus, if we admit that Galley Hill man is truly of the same age as the 100 feet terrace, then his culture is that of Chellean man. The implements of this period often show evidence of high skill in the working of flint.

When the fossil remains of Galley Hill man were discovered, we had only geological data to assist us in fixing their antiquity. Since then a new source of evidence has come to light. In the deposits on the sides of our valley—in the strata of its terraces—there is a complete sequence of the cultural phases of the Pleistocene period. We can trace all the stages which link the cultural debris now being entombed by the Thames in its bed to the pre-Chellean implements which were engulfed when the deepest and oldest stratum of the 100 feet terrace was deposited. Galley Hill man lay in the middle or Chellean strata of that terrace. Those who have studied the sequence of Pleistocene cultures, and have assigned just estimates to each, suppose that the Chellean phase of culture was moving towards its zenith 100,000 years ago. If we base the age of Galley Hill man on cultural evidence, we have to assign to him an antiquity of 100,000 years. If we accept this age, then we have to infer that the type of man now found in Western Europe has come through the greater part of the Pleistocene period without undergoing any great degree of change.

Let us now look at the evidence relating to man's antiquity which has been accumulating these past years on the continent of Europe. The Neanderthal type of man, which we are to investigate first, belongs to the Mousterian phase of culture, one which is much more recent than the Chellean. Most authorities would date the beginning of the Mousterian phase at about 40,000 B.C., and its concluding phase as about 20,000 B.C. All the graves of this long period—from Gibraltar in the south to the centre of Germany in the north—contain remains of only one type of man, the primitive Neanderthal type. The bones of the modern type—Neanthropic man—are never met with. We must thus conclude that the European of the long Mousterian period was Neanderthal man.

Further, the discoveries made at Ehringsdorf, near Weimar, and in the Mauer sands near Heidelberg, have revealed older and more primitive representatives of the Neanderthal type. Heidelberg man is as old as the deepest bed of the 100 feet terrace of the Thames valley; he belongs to the opening phase of the Pleistocene period. Thus all the evidence from the continent leads us to believe that Europe was inhabited by men of the Neanderthal type throughout the greater part of the Pleistocene period. They underwent a considerable degree of evolution before their type was extinguished at the end of the Mousterian period. There are only two items of evidence which clash with this interpretation—namely, the discovery made at Galley Hill, and another at Clichy, in Paris, where human remains, very similar to those of Galley Hill, were found in a stratum of Chellean date.

All authorities are now agreed that the Mousterian period closed some 20,000 years B.C. with the sudden appearance in Europe of men of the modern type. These forerunners of the modern European were big-brained fellows, in every respect of our own type, save that all of them were strong-jawed and had countenances cast in a somewhat rugged mould. A little toning down of these characters would convert them into modern Europeans. It is clear that these forerunners which broke into Europe at the end of the Mousterian period had evolved elsewhere. We have not yet found their cradle-land. I suspect that it will be found in the northern stretches of the Sahara, or perhaps farther to the east—in Arabia or Southern Turkestan. If only we could discover the prototype of the European and assign a geological date to it, we should settle once and for all whether it was possible for men of the modern type to have made a settlement of Europe during the Chellean period, from which they were afterwards expelled by Neanderthal man, or whether his first appearance in Europe was that made at the end of the Mousterian period, when he conquered and extinguished Neanderthal man. If we accept the first alternative, then the evolution of the European type has been slow; if we accept the second, then it has been more rapid. Circumstances force me towards accepting the latter alternative.

Let us turn for a moment to another representative of mankind at the beginning of the Pleistocene period—Piltdown man. I think we are all agreed that his culture was pre-Chellean, and that his period is represented by the deepest and oldest bed of the 100 feet terrace. He thus belongs to an older and more primitive cultural period than that of Galley Hill man. In

form of skull and in size and pattern of brain, this early representative of Pleistocene humanity does not differ markedly from living races; if not actually on our line of descent, the Piltdown type cannot be far removed from it. The anthropoid characteristics of his jaws and teeth are the chief obstacles to placing the Piltdown type on the direct line of our ancestry. We may presume, however, that our direct ancestor had reached as high a stage at the dawn of the Pleistocene period as that attained by Piltdown man. Even then evolution must work with some rapidity if the modern European is to be produced before the Pleistocene period had closed.

We must also take into consideration that remarkable fossil type of man discovered in Java, to which the name Pithecanthropus has been given. We may accept the date ascribed to him by his discoverer, Dr. Dubois, as late Pliocene. He is thus older than either Piltdown man or Heidelberg man. His brain possessed distinctively human features, but it is much smaller, much less evolved than any hitherto ascribed to man. His skull and his brain, so far as we know them, stand midway between the status of ape and man. To transform this ancient type of Java into the most primitive of living human types, evolution would have to proceed at an extremely quick pace. It is easier to believe that Pithecanthropus represents the persistence of an early Pliocene type than that it represents the stage reached in human evolution at the end of that period.

The discovery made in the Broken Hill mine, South Rhodesia, in the autumn of 1921, must also be taken into account. Here was brought to light the fossil remains of a primitive human type. Rhodesian man may be described as the cousin of Neanderthal man, but was more primitive in many respects than any example of Neanderthal man so far found in Europe. Neither the geological nor the cultural age of Rhodesian man is fixed as yet, but we shall not over-estimate his antiquity if we make him a contemporary of the men who lived in Europe at the beginning of the Mousterian period. Neanderthal man became extinct; he was not transformed into modern man. In this respect Rhodesian man differs from him; he could stand very well as an ancestor to men of the Australoid type; he might be on the line along which modern races have evolved. To transform the Rhodesian into the Australoid type within the compass of the Pleistocene period demands a moderately rapid progress; to transform the Rhodesian type into that of the modern European in this space of time would require evolution to move at a rapid rate.

The important discovery which Prof. Dart has made at Taungs, Bechuanaland, has no bearing on the problem we are discussing here. He has found the fossil remains of a young anthropoid ape; it is akin to the chimpanzee and to the gorilla. This discovery throws light on the history of anthropoid apes and upon their evolutionary proclivities, but not, I think, upon the pedigree of humanity.

I have stated the chief facts on which anthropologists have to base their judgment as to the rate at which man has come by the present characters of his body and brain. We are all agreed as to the primitive nature of the human types discovered at Piltdown, Heidelberg, Java and Rhodesia. There is also a broad agreement as to the early dates at which these types lived. If they represent the general stage which evolving humanity had reached in the opening phase of the Pleistocene period, then we must count that man's ascent to his present place has been one of rapid progress. On the other hand, we have the discoveries at Galley Hill and Clichy. The men found in those instances are of our type; if we accept the geological evidence, we have to presume that, so far as our ancestry is concerned, evolution has been stationary throughout the greater part of the Pleistocene period. As evidence accumulates, it becomes easier to reject the geological evidence relating to the discoveries at Galley Hill and Clichy, and more difficult to believe that man in his full-blown modern form could have been the contemporary of the uncouth types discovered at Piltdown, Heidelberg, Java and Rhodesia. In brief, the evidence which accumulates forces us to the conclusion that the evolution of man has been more rapid than many of us have hitherto believed.

I began by showing how much our anthropological inquiries are complicated by the rank degree of variability which prevails among all races of mankind. The same difficulty confronts us when we set out to search for our Pleistocene ancestry. The world of to-day is populated with races of the most diverse types. It was so in remote times, only the population was then sparse and scattered, and the racial types were infinitely more divergent than they now are. Of the early fossil types so far discovered only one—the Rhodesian man—has any claim to a place in the direct lineage of modern races. The stages which lead on to man of the Indo-European or Caucasian type have not been found as yet. It is not until we have unearthed these missing stages that we shall be in a position to pass a final judgment on the rate of man's evolution.

Current Topics and Events.

ON July 3 a deputation from the Australian National Research Council waited upon the Prime Minister of the Commonwealth to present a strong protest against acquiescence in the annexation by France of the Antarctic territory of Adelie Land, an action which was announced by French Presidential decree on November 24, 1924. On behalf of the Council, Sir David Masson (president) pointed out that since 1840, when d'Urville sighted and named, but did not land upon, Adelie Land, no attention has been given by France to this region. British expeditions, on the other hand, costing money and life, have made important additions to scientific knowledge of what, from its geographical position, has come to be known as the "Australian Sector." On the Mawson Expedition of 1911–14, which added 1000 miles of coastline to the map, Australia has already spent 70,000*l.*, and elaboration and publication of valuable results is still in progress. To no other country will further investigation of this sector be of such interest and significance. The progress of meteorological science, for example, will probably make the establishment of observing stations exceedingly important for Australia, for it must be remembered that Adelie Land, due