taken," which involves solution, evaporation, &c., for lead sulphate, filtration, and submitting the solution to ordinary chemical tests. This is surely not a method adapted to the use of "miners and prospectors."

With regard to assaying, in the case of copper ores not one of the ordinary methods of assay is given, and the ordinary method for assaying silver ores finds a place in an addendum to the volume. The whole book affords additional evidence of the prevalence of the belief in the fallacy that a chemist must of necessity be acquainted with a subject so dependent on his own, yet so widely differing from it, as metallurgy.

OUR BOOK SHELF

Microbes, Ferments, and Moulds. By E. L. Trouessart. "International Scientific Series." (London: Kegan Paul, Trench, and Co., 1886.)

THIS book, which aims at the instruction in microbes not so much of the medical and scientific as of the general public, is a fairly accurate exposition of the present state of our knowledge of the morphological and physiological characters of moulds and bacteria.

The chapters on fungi and moulds, of the various ferments and yeasts, and their chemistry, are the best parts of the book. Those on bacteria, septic and pathogenic, are less commendable, since they contain a good many dogmatic statements not accepted by bacteriologists. The chapter on laboratory research and culture of microbes is imperfect in its account of the now generally employed methods of cultivation on solid nutritive media.

One of the most conspicuous deficiencies of the book in the eyes of the scientific reader is the one-sided account given by the author of many of the discoveries made in bacteriology, since the works of French authors form as it were the basis of the author's account. It is certainly a novel proposition that "the science of microbes is essentially a French science."

The book is well illustrated, and written in a clear and concise manner.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

Luminous Clouds

THE clouds described by D. J. Rowan, on p. 192 in your issue of the 1st inst., seem to have been of the same kind as were described in several letters in NATURE last summer; they were seen by myself in Bavaria. I saw these extraordinary clouds again this year, on the 28th of May, at Freshwater Bay, Isle of Wight, and on the 23rd of June at Bideford. They were seen by A. C. Dixon at Sunderland on the 2nd, 3rd, 13th, 16th, 22nd, and 23rd of June, and on the latter date were very striking. A description of them on the same date, written by E. Greenhow, appeared in the *Newcastle Chronicle*, as seen near Earsdon in Northumberland, erroneously describing them as a kind of aurora. On that night the display at Bideford was comparatively slight: at 10.18 p.m. the upper limit of the clouds distinctly visible was five-eighths of the way from the horizon to γ Andromedæ, and I presume that that was the limit to which the sun was shining upon them; though with field-glasses I could see them very faintly rather higher up.

I never saw them before last summer, and they are quite different from the iridescent clouds that have created such interest the last two winters, resembling them only in their height and brilliancy. If they require a name I hope the word *boreales*, as proposed by Mr. Rowan, will not be adopted; for they appear in the north only because the sun lies in that direction, and if they occurred at any other time of the year, or in any place much further south than this country, their direction would necessarily be different. On all the occasions which I have seen these clouds they have exhibited a very fine structure like cirrus. The colours of the clouds appear to be due to the same cause as the colours of the sky, for they generally correspond with these at similar altitudes, the upper visible portion of the sheet of clouds being green or bluish, and the lower portion a dull yellow, becoming more orange towards the horizon.

Sunderland, July 8 T. W. BACKHOUSE

Re Immisch's Thermometer

IN your article, p. 234, referring to this pretty little instrument, you refer to the appellation "metallic" as not a happy one in describing it. This I pointed out to the maker some time ago, and termed it an *avitreous* thermometer, as glass plays no part in its construction beyond that of a protector to the dial. The certificates of verification are printed with the instrument so designated, and probably the erroneous term will soon drop out of use. I must also crave permission to correct a misprint in your correspondent's statement with regard to the number of avitreous thermometers verified here up to the present date: for 500 read 300. G. M. WHIPPLE,

Superintendent Kew Observatory

Kew Observatory, July 10

Kirby and Spence's "Introduction to Entomology"

WITH reference to a just complaint made by "R. M." in his article contained in NATURE for July 1 (p. 190) about the want of good indexes to books, and specially to the early editions of Kirby and Spence's "Introduction to Entomology," may I venture to inform him that should an index to the latter book be desired by "R. M." or any other reader of NATURE, they have only to apply to "E. E. J.," Camerton Court, Bath, to obtain one *gratis*. I found the book so perfectly useless for want of one, that I made one some years ago, a copy of which was accepted by the British Museum authorities, and is now included in their Catalogue. I have a good many copies on hand, which I am always glad to give away on application.

E. E. JARRETT

11, Holles Street, London, W., July 8

ON VARIATIONS OF THE CLIMATE IN THE COURSE OF TIME[1]

II.

IF such a periodical variation in the climate does take place, we should be able to trace it in the older formations, as we cannot assume that it first began to operate in the most recent geological age. We must, therefore, try to discover if such variation can be traced in the earlier times.

During the melting of the Norwegian inland ice it left here and there moraines, and on the map drawn by Kjerulf they are seen to stretch in lines more or less continuously across large parts of Southern Norway. On both sides of the Christiania fjord the outside lines, the so-called "Raer," stretch like gigantic ramparts from Moss and Horten south-east and south-west many miles wide through Smaalenene and far into Sweden, and, on the other side of the fjord, through the province of Jarlsberg and Laurvig to Jomfruland outside Kragerö. And behind this outside line of moraines others follow in more or less broken but distinct continuity, one behind the other, through all Southern Norway. These lines show that the

[1] The following is a short abstract from various papers, viz.: "Essay on the Immigration of the Norwegian Flora during Alternating Rainy and Dry Periods" (Christiania, 1876). "Die Theorie der wechselnden kontinentalen und insularen Klimate," in Engler's *Botanische Jahrbücher*, ii. (Leipzig, 1881). "Ueber Wechsellagerung und deren mutmassliche Bedeutung für die Zeitrechnung der Geologie und für die Lehre von der Veränderung der Arten," in *Biologisches Centralblatt*, iii. (Erlangen, 1883). "Ueber die wahrscheinliche Ursache der periodischen Veränderungen in der Stärke der Meeresströmungen" *l.c.* iv. (Erlangen, 1884). Continued from p. 223.

ce did not recede gradually, because it would not then have left behind such great ramparts, but the sand and the gravel would have been spread more evenly. During the melting, however, its edge remained at times stationary, or advanced perhaps a little. At each such event a row of moraines was formed, and as the same are found in large tracts of the country, they cannot be attributed to local circumstances, but we have to assume *that periodical variations of climate were the cause of the manner in which the ice receded.*

We found in the peat-bogs alternately layers of different kinds, peat alternating with remains of forests several times, and we saw how this was easiest explained by periods of change in the climate. But these alternating layers are not peculiar to the peat alone, but found in all stratified formations, loose as well as solid, whether deposited in fresh or salt water, or on land, in all the strata from the Laurentian gneiss to the loose deposits of the present age. Take a geological structure from any age, alternating layers will be found everywhere. Sand alternates with gravel, sandstone with conglomerate, clay with sand, slate with sand or sandstone, marl with clay, chalk with marl, and so on. The layers vary in thickness, from several yards to less than an inch.

The solid rock withers away by the action of air and water in heat and cold; it partly crumbles away mechanically and partly changes chemically. The products of the erosion are carried by wind or running water as dust, in dissolved or original state, and deposited in places more or less remote from those where they were produced. The foaming mountain stream often carries great stones in its course, and the softer the wind and the weaker the current the finer is the matter deposited. When the current becomes weak the gravel sinks first, then the sand, then the clay, and, finally, the chemically-dissolved lime by the animal life in the water. When we, therefore, have a change of beds of different composition through all geological ages, as those mentioned above, it must be due to the circumstance that the speed of the depositing stream was always varying—now increasing, now decreasing.

The *Challenger* Expedition has taught us that all the stratified rocks which geologists hitherto have known must have been formed comparatively near the shore, even if deep-sea formations. They are all of quite a different nature from the strata in the abysses of the great oceans. From this it follows that the variations in the rainfall might have had some influence on the nature of the strata in the known geological formations, since they were formed comparatively near land and are the result of the erosion of the solid rock. A weak river is unable to carry debris far out to sea, but a strong one is capable of supplying the sea-currents with deposits over great areas. When, therefore, the rivers alternately increased and decreased, the sand, clay, and gravel were carried now a greater, now a less distance, into the sea, and thereby the variations of the layers were produced.

It is, however, not the intention to assert that all alternations of layers are due to that long climatic period. When the stratification goes on quickly, and the supply of matter is plentiful, rapid local changes may produce an alternation of strata. In the Norwegian marl-clay, formed during the melting of the inland ice, alternating thin layers of sand and clay are found, varying in colour, sometimes only a quarter of an inch in thickness or even less. These variations must be ascribed to changes during brief spaces of time, and cannot be referred to the long climatic periods. But, of course, such layers are only formed in the immediate vicinity of the coast, and during the constant advance and retrogression of the latter, which may be traced through all geological ages, such shore-formations were most exposed to destruction. They were frequently lifted above the sea, and were more exposed to the destructive agencies—air and currents—than those formed in deeper waters further from the shore. For this reason these quickly-formed layers have at all times been more exposed than others to destruction, and we must, for that reason, conclude that most of the beds which constitute the geological stratified deposits were formed somewhat further from the shore, and that, consequently, the time of their formation was longer. From the thickness of the layer alone it is impossible to form an idea of the time it has taken to form, because in the time a layer in one place upwards of several yards in thickness has been forming, only an inch has formed in another, whilst in a third place in the same time the formation has ceased, or older layers even carried away. But we have a means whereby we may ascertain the time it has taken to form a layer, viz. the study of the remains of the flora and fauna found in the same. The most frequent species have, *ceteris paribus*, the most chance of being preserved. When, therefore, we find that fossils, as is often the case, vary from stratum to stratum, we must assume that this proves that great changes took place in the fauna and the flora during the formation of each stratum. What was stated above with regard to the variations in the peat-bogs of remains of plants from layer to layer *may be applied to variations of strata through all ages.* The examination of the fossils in the strata teach us respect for Time. The fossils vary quickly even in strata of small thickness. In one stratum we find remains of distinct animals and plants, and in the one above—although, perhaps, only an inch above it—we find others quite different. A thin stratum of a couple of inches is sometimes distinguished by peculiar animals and plants, so that the stratum may be recognised over large areas by the aid of the same. When two strata of different nature alternate, it is generally found *that one kind of stratum contains certain fossils, and that those of the others are quite different.* The theory of periodical variations of the climate *explains all this.* Because if the sea-currents varied in strength, the temperature of the water, and consequently the aquatic fauna and flora, must have changed too; with a higher temperature of the sea the moisture of the air and the rainfall must have increased, *and thus a periodical change of the sea-currents would have the effect of causing variations of the strata.* It is exactly such strata of varying nature, and varying forms of fauna and flora, which would build the geological strata of the earth.

We have seen how this theory explains a number of various well-known puzzles to scientific men, viz. the scattered extension of species of plants and animals; the formation of the terraces of shell-banks and shore-lines; the rows in which moraines appear; and, finally, the alternation of peat-layers and various geological strata. It only remains now *to find a natural cause for such a periodical variation of the climate*, but before doing this it is necessary clearly to understand what the theory demands.

It does not require great changes; all the facts on which it is founded may be explained by comparatively small variations in the extremes of temperature and rainfall. No very great variation is required in order that the holly and similar coast-plants should be able to grow by the Christiania fjord, as the theory assumes it once did; because the holly, which cannot stand the winter cold at Christiania (lat. 60° N.), has for many years been successfully cultivated in the open air at Horten, only half a degree further south on the same fjord. And along the coast plants of Oriental origin have, during the last thousands of years, spread from the Christiania and Throndhjem fjords right out to the open shores of Jæderen and Fosen, the former in lat. 58°–59° and the latter in lat. 63°–64° N., and there would hardly be required a very great change to enable them to grow also in the intervening district, the province of Bergen, which would again make their extension continuous.

Whether the surface of a bog becomes covered with forest or not, whether the peat grows or not, whether during the rising the erosion is strong enough to hollow out the shore-line, or the carrying power of the river is great enough for the formation of terraces, whether the edge of the inland ice recedes or advances, whether a deposit of clay or marl is to be found in a certain place near the shore, or whether chalk only is left—*may entirely depend on small variations in the climate, as the conditions will alter as soon as a certain point is reached.* The periodical changes dealt with here were therefore not great; but as they acted simultaneously, and in the same direction, over whole climatic areas, it must be generally-acting forces which caused the same, and not variations in local conditions.

The theory advanced here proves thus that the climate is at all times subjected to periodical changes, the duration of which may be measured in thousands of years, and which act in the same direction within the same climatic area, which for one period are not important, but which, as the alternation of the strata is often remarkably regular, *seem to return after the lapse of a fixed cycle of years.*

It is obvious that periodical changes in the strength of the ocean currents will cause corresponding changes in the climate of the adjacent continents. Thus, for instance, if the warm North Atlantic current, to which North Europe owes its climate, which is mild compared with its latitude, should increase in strength, the climate there would doubtless become still milder. Our shell-banks show that such changes in the temperature of the sea have accompanied climatic variations. We are, therefore, compelled to ask, What is the force which causes this warm sea-current to flow northwards, and may we assume that there is some natural cause effecting periodical changes in the intensity of this force? The question being one as to a climatic period, we must examine the great laws which govern the climate. We must, of course, leave all temporary disturbances of the air out of consideration, and only pay attention to the great and simple laws which are revealed by the synoptic charts of the average distribution of the aërial pressure at various seasons. These charts show us:—in the summer a low pressure over the heated continents, but generally a higher one over the cool oceans; and in the winter a higher pressure over the cold continents, and a lower one over the oceans, which are warmer.

In order to understand this varied distribution of pressure, we shall imagine an atmosphere which everywhere has the same degree of heat and the same height. The warmer the air the more it expands, so that the height of the atmosphere will change if the temperature rises or falls. If we further assume that the air cools or becomes more quickly heated in some places than others, the equilibrium will be disturbed. Over cold areas the height of the atmosphere will decrease. The surface of the atmosphere should thus become uneven, and consequently, in the upper strata of the atmosphere air must flow from the warm regions into the cold ones, so that equilibrium be maintained. For this reason a greater mass of air will lie over cold regions, which have, therefore, a higher atmospheric pressure. But at the surface of the earth, too, the equilibrium will be disturbed, as a higher atmospheric pressure will drive the air from the cold to the warm regions. As long as the temperature of the air varies, movements will be created by the disturbed equilibrium, during which, therefore, air will flow from the cold to the warm regions along the surface of the earth, and *vice versâ* in the upper part of the atmosphere. In winter as well as summer the disturbances of the equilibrium of the atmosphere will proceed from the continents, because the latter are heated and cooled more intensely than the oceans. Over the ice-covered interior of Greenland the sun in the summer cannot create any low pressure, because all its heat is consumed in melting the snow. Even in the summer comparatively cold air and high pressure prevails over Greenland, and this is probably the cause of the atmosphere in the North Atlantic differing from the above-mentioned law, inasmuch as this ocean has a low pressure even in summer. This low pressure, which lies generally near Iceland, is, however, more marked in winter.

The air, according to the law of Buys Ballot, moves *against* the low pressures, so that in the Northern Hemisphere one has the low pressure a little in front to the left when turning the back to the wind. That is but a natural consequence of the rotation of the earth's axis. At lower latitudes this action is more intense. Air, flowing from lower to higher latitudes, retains for a time its original speed of rotation, and will thereby deviate in the direction of the rotation of the earth's axis, *i.e.* towards the east. And *vice versâ* when the air flows from higher to lower latitudes. In this manner southerly winds become south-westerly, and northerly ones north-easterly. In fact, the low atmospheric pressure at Iceland draws the south-west winds up the North Atlantic, and as the cause prevails all the year round, the consequence is that south-west winds blow in this sea summer as well as winter.

The opinion held by Croll, Zöppritz, &c., that winds are the chief cause of sea-currents, is now generally accepted by *savants*. The winds set the surface of the sea in motion, and by frictional resistance the movement is conveyed to lower depths. It depends on the force and the duration of the wind how deep the action will have effect. The main current runs in the direction of the prevailing wind, and its speed is dependent on the average speed of the surface. Winds of short duration are only capable of changing the direction of the current on the surface, but through the *predominance* of such winds through thousands of years, *great currents are created.* Their strength may vary, *but their direction is independent of temporary changes of the wind.* For the upper system of currents, which alone affects the climate, and which reaches to a depth of a couple of hundred fathoms (Mohn), the average direction and force of the wind during the last great epoch are determinal.

Such a great stream is the warm North Atlantic current. It softens the winter even at high latitudes. As the surface imparts heat to the air, the heat lost is replaced from lower depths, and as long as there is a store of heat below the sea will always yield heat to the air.

The mild climate of Norway is, therefore, dependent on this warm current. It runs predominantly in a north-easterly direction, and thus it must, in consequence of the general laws for currents and winds, have run through untold ages, or as long as sea and land have been divided as at present.

We will now see if the force which guides this current is periodically changeable. As we know, the orbit described by the earth round the sun is not circular but elliptical, so that the distance between the two bodies varies according to the seasons; when there is winter in the Northern Hemisphere the earth is nearest to the sun, and the nearer the earth approaches the sun the quicker it travels, so that the winter in the north is shorter than the summer. The difference is five days. In the Southern Hemisphere, on the other hand, the winter is five days longer than the summer. But these relations change through the precession of the equinoxes, the period having a mean duration of 21,000 years. Thus, 10,500 years ago the conditions were the reverse of what they are at present, and the same will be the case 10,500 years hence. The winter at the Northern Hemisphere will then fall when the sun is furthest from the earth, and last longer than the summer, and in the Southern Hemisphere the conditions will be the reverse.

But the orbit of the earth is also subjected to periodical changes, inasmuch as it differs more from the circular sometimes than at others. The further it deviates from it the greater becomes the difference between the length of winter and summer, and the difference may even amount to more than thirty days every year. The length of winter and summer varies therefore in the course of 10,500 years, and the difference increases the more the earth's orbit deviates from the circular. During the 10,500 years in which the winter is longer than the summer there will be several thousand more winter days than summer ones, and in the second half-cycle there will be as many thousand less. Even at present, when the orbit deviates but little from the circular, the excess of winter or summer days for each half-cycle is more than 50,000, and when the deviation is greatest it amounts to nearly 220,000 days, or some 600 years.

As the cooling of the continents contributes to preserve the low atmospherical pressure over the oceans, and thus directs the prevailing winds and currents at sea, the winds thus directed, as, for instance, the south-west winds of the Atlantic, must be stronger in winter than in summer. *And this is indeed the case.* The weather conditions differ in summer and winter. Of course south-westerly winds blow predominantly in the North Atlantic and West Europe all the year, *but they predominate more in the winter.* According to Prof. Mohn, their force in the North Atlantic is about three times as great in the winter as in the summer, and similar conditions prevail in the Pacific Ocean. In the southern temperate seas north-west winds, which correspond to south-west ones with us, are equally predominant when there is winter in that hemisphere. It will therefore be seen that the forces which promote the warm sea-currents in our latitude *are most active in the winter.* And the same is the case in the Southern Hemisphere, so that it must be said that the winter favours these currents, whether it falls when the sun is nearest, as with us, or when it is most distant, as in the Southern Hemisphere. From Prof. Zöppritz's studies of the currents it appears that the wind exercises an influence upon the strength of them even long after it has ceased to blow. The action of the winds is summed up through centuries, *and the total recorded in the sea-currents.*

As we know that the wind conditions vary at different seasons, and that the effect of the wind does not cease as soon as it is discontinued, but leaves traces in the sea-currents for a long time after; so that, in fact, the strength of the current is dependent on the average force of the wind during last great ages—it can hardly be a matter of indifference whether these thousands of days fall as a surplus to winter or summer in the 10,500 yearly half-cycle. When they fall in the winter, the south-west winds must be more predominant than others; and, correspondingly, when they fall to the summer, weaker. It seems, therefore, reasonable that the currents must increase or decrease as the equinoctial line moves round. When the winter falls in aphelion our warm currents will increase, and when the reverse is the case they will decrease. We should, therefore, now in the Northern Atlantic have a weaker current, and in North-Western Europe less rain and a greater difference between winter and summer heat, *and this is exactly what the theory demands.*

In regions with different weather conditions the case will be different. For instance, in the eastern part of North America north-west winds are more predominant in the winter and south-west ones in the summer. Winter, in aphelion, would here increase the north-west wind, and one might conclude that these parts under such conditions would perhaps thereby obtain a more severe climate, so that it seems evident that variations in the climate will not simultaneously move in the same direction everywhere in the Northern (or Southern) Hemisphere.

From calculations we have elsewhere demonstrated that the varying length of the season alone during the precession of the equinoxes will cause an increase or decrease in the force of the current of several per cent. of the total. And these figures are doubtless below the true ones, but space does not here permit of developing them. We may, therefore, with a high amount of probability conclude *that the precession of the equinoxes causes periodical variations of the climate which are great enough to explain all the facts on which the theory for these periodical variations is based.*

But the eccentricity of the earth's orbit changes so rapidly that in two consecutive half-cycles it is not as a rule the same. Therefore variations in the strength of sea-currents, and consequently also those in the climate in one half-cycle will not be quite balanced in the next, and it might even be possible that greater and more lasting variations of the climate might be caused by the same agencies.

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The University, Christiania

VEGETABLE PRODUCTS AT THE COLONIAL AND INDIAN EXHIBITION

IN passing through the various courts of the Colonial and Indian Exhibition the prevailing natural resources of each colony are apparent even to the most unobservant, for while the riches of some countries are to be found chiefly in their vegetable products, the wealth of another is in its mineral resources, and of another in its animals.

Regarding the vegetable products, as might be supposed, some of the most interesting objects from a scientific point of view are those which have the least attraction for the general public, such, for instance, as the large and varied collection from the Straits Settlements, or the interesting exhibits from British North Borneo. Amongst the exhibits from the former possessions are various samples of damar, the botanical origin of which is but imperfectly known; thus, for instance, are specimens of damar sesa, a fossil resin from Larut, Perak, damar meta kuching, or cat's-eye damar, damar renkong, and others. Another fossil resin new to us is called incense or gum Benjamin. Under the name of buah saga are shown some seeds of an *Adenanthera*, probably those of *A. pavonina*, a seed of which is the unit in the Malay jeweller's weight, equal to 4·33 grains troy. The seeds are also eaten by the natives. The tree is found in India, China, and the Philippines. In India the wood, which is of a red colour, hard, and close-grained, is known as red sandal-wood, and is used as a red dye, as well as for cabinet-making and building purposes. On account of their bright red colour the seeds are used as necklaces. Naturally in countries where the bamboo is abundant we should expect to find numerous illustrations of its uses, and various articles of domestic utility, as well as for other applications besides that of ornament, are shown, some of which are very ingenious, such as a trap called grôgoh, used for catching river fish; it is somewhat of the shape of an eel-pot, and the body of the trap is made of a single piece of bamboo-stem of about 2 inches diameter, and from 14 to 18 inches long. It is split longitudinally for the greater part of its length into fine strips, these are distended to a wide mouth at the top some 6 or 8 inches diameter, tapering to the point from which they spring, where they form the natural stem. By the addition of other fine strips of bamboo fastened round at short intervals a complete funnel-shaped basket or eel-pot is made, the lower or tubular end of which is formed by the hollow bamboo-stem. The ready way in which the natives adapt natural productions is seen in a very simple spinning-top, which is composed of a flattened acorn of the type of *Quercus placentaria*, through the centre of which a piece of wood is driven. In this division also are some very varied sets of betel-chewing appliances as used by the Malays, including the scissor-like implements used for cutting the betel-nuts; many of these sets are in deftly-worked brass, while others are in more costly metals.