cruises, the first off the north-west and the west coasts of Ireland, the second off the south and south-west coasts of Ireland, and the third off the north of Scotland as far as the Faroes. In 1870, the *Porcupine* dredged down the west coasts of France and Spain and in the neighbourhood of Gibraltar Strait, and explored the African coast of the Mediterranean as far east as Sicily. Prof. W. A. Herdman contributes to the Transactions the Report upon the *Tunicata* dredged during the cruises of H.M.SS. *Porcupine* and *Lightning* in the summers of 1868, 1869, and 1870. The Simple Ascidians alone are treated of. The Report on the *Pennatulidæ* dredged by the *Porcupine*, is by Prof. Milnes Marshall and Dr. G. H. Fowler. One new genus and one new variety were obtained. Dr. P. H. Carpenter writes "On the *Crinoidea* of the North Atlantic between Gibraltar and the Faroe Islands," and some notes are added by Prof. L. von Graff on the *Myzostomida*. The Report on the *Ophiuroidea* of the Faroe Channel, mainly collected by H.M.S. *Triton* in 1882, is drawn up by Mr. W. E. Hoyle. Mr. Hoyle also gives the second part (on the *Decapoda*) of a preliminary Report on the Cephalopoda collected by H.M.S. *Challenger*.

Mr. J. T. Cunningham (then of the Scottish Marine Station) writes on the "Eggs and Larvæ of Teleosteans;" on the "Reproductive Organs of *Bdellostoma*, and a Teleostean Ovum from the West Coast of Africa;" on *Stichocotyle nephropis*, a new Trematode, found as a parasite in the Norway lobster; and, along with Mr. Rupert Vallentin, on the "Luminous Organs of *Nyctiphanes norvegica*." Mr. George Brook discusses "The Formation of the Germinal Layers in Teleostei." Mr. Harvey Gibson gives a detailed account of the anatomy of *Patella vulgata*, no systematic account having been previously given, though separate accounts of various organs have appeared. Mr. Frank E. Beddard writes "On the Minute Structure of the Eye in certain *Cymothoidæ*;" "On the Structural Characters of certain new or little known Earthworms," five apparently new species and possibly a new genus being described; and "On the Reproductive Organs of the Genus *Eudrilus*." Mr. J. Arthur Thomson describes the structure of *Suberites domuncula*, a sponge found covering the outside of a sea-snail shell inhabited by a hermit-crab.

In geology some important papers appear. Dr. Traquair contributes the first part of a Report on fossil fishes collected in Eskdale and Liddesdale (*Ganoidei*). Mr. R. Kidston gives the first two parts of an account of the fossil flora of the Radstock series of the Somerset and Bristol coal-field (Upper Coal Measures). A note is appended on the fossil flora of the Farrington, New Rock, and Vobster series, and a table is given comparing the flora of the Radstock series with that of other coal-fields. Mr. Kidston also discusses the fructification of some ferns from the Carboniferous formation. Prof. Geikie writes on the geology and petrology of St. Abb's Head. The final Report of the Boulder Committee of the Society is contained in the Proceedings.

The plates in Vol. xxx. accompanying a paper by Dr. Traquair on fossil fishes are of great artistic merit. Indeed, the illustrations which are contained in the Proceedings and Transactions are probably unsurpassed by those published by any other similar Society.

Observations by Dr. H. B. Guppy, of H.M.S. *Lark*, on coral reefs and calcareous formations of the Solomon Group, appear in both publications. He is led to the conclusions: (1) that these upraised reef-masses, whether atoll, barrier-reef, or fringing-reef, were formed in a region of elevation; (2) that such upraised reefs are of moderate thickness, their virtual measurement not exceeding the limit of the depth of the reef-coral zone; (3) that these upraised reef-masses in the majority of islands rest on a partially consolidated deposit which possesses characters of the "volcanic muds" which were found during the *Challenger* expedition, to be at present forming around volcanic islands; (4) that this deposit envelops anciently submerged volcanic peaks. The bearing of the two latter conclusions on Dr. Murray's theory of the formation of coral islands is important.

We conclude with another quotation from the address already referred to:—"With respect to Scotland, the only grant for scientific purposes in aid of learned Societies is £300 annually to the Royal Society of Edinburgh, which is repaid to a department of the Government in the form of rent. One might well ask what Scotland had done that her learned Societies and scientific men should be treated so niggardly as compared with those in England and Ireland. It cannot be because she does no scientific work. It is sometimes said, indeed, that in literary matters Scotland, and especially Edinburgh, is a mere shadow of her former self; but in science this is not the case, and it is towards scientific matters that the great ploughshare of human thought and activity is, in this age, directed. I question if any country in the world, taking into consideration its size, can show a better record of scientific work, or a more excellent volume of scientific literature than Scotland, during the past ten or twenty years."

TIME.

TIME is one of the very numerous subjects which seem to be perfectly simple until we begin to think about them; then difficulties crop up in all directions, and afford a favourite battle-ground to philosophers.

Newton, avoiding metaphysical difficulties, gave an account of time which suffices for all the purposes of the mathematician and experimentalist. "Absolute, true, and mathematical time of itself and from its own nature flows equably and without regard to anything external, and, by another name, is called duration; relative, apparent, and common time is some sensible and external measure of duration by means of motion."

The word time is here used to express two distinct ideas, for the former of which it would be better to reserve the term duration. This double meaning of the word has caused much controversy between idealists and materialists, which is still far from arriving at any definite result. Thus, Whewell writes ("Hist. Ind. Sci.," 131):—"Time is not a notion obtained by experience." "Time is a necessary condition in the presentation of all occurrences to our minds. We cannot conceive this condition to be taken away. We can conceive time to go on while nothing happens in it, but we cannot conceive anything to happen while time does not go on."

It has always seemed to me that philosophers are rather hard on the intellect of their fellow-mortals in laying down so absolutely, as they are fond of doing, what can and what cannot be conceived by the mind, when they are in reality arguing from a single instance—their own. Many persons would be tempted to say that the idea of the fourth dimension of space is inconceivable, did not men of more powerful intellect assure them that their crude ideas on the subject are quite erroneous. I can myself find no impossibility in the conception of a universe composed of a homogeneous mixture of gases, to which the ordinary conception of time does not apply. If I err, I I at least do so in good company. Lucretius writes (i. 460):—

> "Tempus item per se non est, sed rebus ab ipsis
> Consequitur sensus."

And, in 1690, Locke gave the following luminous exposition of this difficult matter ("Hum. Und.," xiv.):—"A man having, from reflection on the succession and number of his own thoughts, got the notion or idea of duration, he can apply that notion to things which exist while he does not think; as he that has got the idea of extension from bodies by his sight or touch can apply it to distances where no body is seen or felt." "Thus, a man when he is asleep, or when his mind is entirely occupied by one subject, has no notion of the passage of time." "This consideration of duration, as set out by certain periods and marked by certain measures or epochs, is that, I think, which most properly we call time."

According to Locke, then, duration is measured out, as it were, into time by changes, and as these changes are, so far as we know, due to motion, the ideas of time and motion are closely connected. These views have been further developed by Herbert Spencer ("First Principles," 163, 167, 171):—"The relation of sequence is given in every change of consciousness." "The abstract of all sequences is time. The abstract of all co-existences is space." "The conception of motion, as presented or represented in the developed consciousness, involves the conception of space, of time, of matter—a something that moves; a series of positions occupied in succession; and a group of co-existent positions united in thought with the successive ones." "These modes of cohesion, under which manifestations are invariably presented, and therefore invariably represented, we call, when contemplated apart, space and time; and when contemplated along with the manifestations themselves, matter and motion."

The abstract idea of duration without beginning or end is of the greatest value to the mathematician, but, so far as we know, it has no representative in Nature. It would, of course, be measured out by the equal spaces passed over by a body moving under the action of no forces, but no known body is in such a condition. As possible instruments for the accurate measurement of time, Thomson and Tait suggest a spring vibrating *in vacuo*, and Clerk Maxwell the period of vibration of light-waves of definite length. From this conception of duration or equable flow, Newton deduced his method of fluxions, which, owing to his delay in publishing the method, occasioned the lamentable controversy as to priority with Leibnitz. Though the manuscript of Newton's first paper on fluxions has been found with the date May 20, 1665, it was only communicated in a letter to Collins in 1672, used in some papers on motion read before the Royal Society in 1683, and printed in 1684. The method was first definitely published to the world in the "Principia," in 1687. According to Maclaurin: "In the doctrine of fluxions, magnitudes are conceived to be generated by motion, and the velocity of the generating motion is the fluxion of the magnitude." Suppose a movable point, starting from a fixed point, A, describes a line AB, of length x, Newton represented by $\dot{x}$ the velocity with which the line is described. Again, the velocity itself may not remain constant, but either increase, as when a stone falls, or decrease, as when a shot is fired. This change of velocity, now called acceleration, was expressed by $\ddot{x}$.

The conception of velocity is passing over a certain space in a certain time, as a mile in a minute or 88 feet in a second, and we may conceive both space and time to become infinitesimally small, so that the ratio of the one to the other becomes a fluxion. Acceleration is measured by the number of units of velocity gained or lost in the unit of time; thus, the acceleration due to gravity is a velocity of 32 feet per second gained or lost in a second.

The discussion of the connection between this conception of fluxions and the various methods of conceiving space as made up of infinitesimal portions, which were used more or less imperfectly by various mathematicians, until they were generalized and systematized by Leibnitz into the differential calculus (1675), would occupy too much space. A fluxion or differential, as was clearly pointed out by Newton, depends upon the philosophical conception of a limit, the foundation of so many of the higher branches of mathematics.

Important as are these theoretical questions deduced from the idea of duration, the practical questions of time and the means of measuring it with accuracy are far more so.

Since astronomers have been unable to find any truly equable motion by which to measure equal intervals of time, they make use of a fictitious sun, which apparently moves round the earth in the same period as the real sun does, alternately before and after it, but coinciding with it four times in the year—on April 15, June 14, August 31, and December 24.

The interval between two apparent passages of the fictitious sun over the meridian is a mean solar day, which is divided into 24 hours, 1440 minutes, or 86,400 seconds. The length of the tropical year, or the interval before the return of the sun to the same equinox, is 365·2422 mean solar days.

In the observatory, astronomers use as their unit the sidereal day, or the interval between two appearances of the same star on the meridian; owing to the apparent motion of the sun, there are 366·2422 sidereal days in the tropical year, or a mean solar day is equal to 1·0027379 sidereal days. About March 22 of each year, sidereal o hour coincides with mean noon, and for each day from that date the difference increases by 3 minutes 56 seconds. For purposes of calculation, astronomers make use of "the Julian period" of 7980 tropical years, of which 1889 is the 6602nd; and at mean noon on January 1, 2,411,004 mean solar days of the period had elapsed.

The oldest time-measurer, the sun-dial, dates from, at all events, 700 B.C. In its most simple form it consists of a style fixed parallel to the axis of the earth, and a graduated circle upon which the shadow falls. The clepsydra, or water-clock, in which time is measured by the equable flow of water, was introduced into Rome about 150 B.C.; and various methods of indicating the quantity of water which had flowed out by bells, hands, figures, &c., were subsequently added. A simple form of the instrument is still used in physical laboratories for measuring intervals of a few seconds. The replacement of water by sand furnished the hour-glass used by our ancestors for measuring out the eloquence of their preachers, as their more feeble descendants now use the three-minute glass for measuring the boiling of their eggs. A transit-instrument affords a ready means of correcting a clock; and mean-time signals are now sent from Greenwich to many places in England; hence in practice we individually measure only comparatively short intervals of time, correcting our private clocks and watches by public clocks regulated by time-signals.

Of all measures, those of time are most frequently and most accurately made. Public clocks are far more numerous than public standards of length or mass, and in 1880 the value of the clocks and watches imported amounted to £880,000. Few persons carry a foot-rule costing say 1*s*., but many a watch costing more than £2. Even among engineers but little attention is paid to lengths less than 1/64 of an inch; and few common balances indicate a difference of 1/100 of the load. But, according to Mr. Rigg (Cantor Lectures on Watch-making, 1881), a watch that does not vary more than half a second per diem, or 1/172800, is frequently met with, while an accuracy of two or three minutes per week, 3/10000, is attained even by cheap articles. It is no uncommon occurrence to meet with a chronometer which does not vary one-fifth of a second in twenty-four hours, or by about 1/432000 of the time measured out.

Almost all modern instruments for measuring time consist of three essential parts: (1) a motive-power, such as a falling weight, an uncoiling spring, an electric current; (2) a regulator, to render the motion steady, such as a pendulum, a balance-wheel, or a magnet; (3) some means of indicating the space passed over, such as hands, bells, or marks on paper.

About the eleventh century the motive-power of a stream of water or sand was replaced by a falling weight; and in the early part of the sixteenth century, Peter Hele, of Nürnberg, substituted a coiled-up spring for the weight. As is often noticed when a foreign clock is wound up, the motive-power of such a spring varies very much as it uncoils. This difficulty was overcome in 1525 by the invention of the fusee, the increased leverage of which compensates for the decreased power of the partly uncoiled spring. In modern going-barrel watches reliance is placed on the careful adjustment of the regulating machinery; while in chronometers a very long spring is wound up so frequently that it never uncoils beyond a very small extent. In 1840, Wheatstone proposed a method of conveying the motion of a standard clock to several others by a current of electricity, and the electric current has since been used both as a motive power and as a regulator.

But little is known about the early methods of regulating clocks and watches, but, according to Shakespeare, the result does not seem to have been satisfactory, though some may consider his testimony invalidated by the accompanying libel ("Love's Labour Lost," iii. 1, 191). Biron speaks:

> "What I, I love, I sue, I seek a wife!
> A woman, that is like a German clock,
> Still a-repairing, ever out of frame,
> And never going aright, being a watch,
> But being watched, that it may still go right."

The use of clocks in observatories (1500), and for finding longitudes at sea (1530), caused a demand for better instruments which was only slowly met.

Galileo is said to have discovered the isochronism of the pendulum before about 1590, by observing a lamp swinging in the Cathedral at Pisa, but the discovery, though used by him, was not published until 1639, and it is doubtful if he applied it to clocks. In 1673, Huyghens proved the isochronism of the cycloidal pendulum, and showed that a pendulum could be caused to vibrate in a cycloid by making the upper portion of the suspending arrangement of steel springs or silk fibres, which wrap round cycloidal cheeks. The cycloidal cheeks are not found to answer in practice, but many makers use one or two parallel steel springs, which causes the bob to describe a curve which falls within the circle, and adds a positive and negative accelerating force at the commencement and end of each swing.

The time, t, of one swing of a simple circular pendulum of length l, at a place where the acceleration due to gravity is g, is—

$$t = \pi \left\{ 1 + \left(\frac{1}{2}\right)^2 \frac{\text{vers } \theta}{2} + \left(\frac{1 \cdot 3}{2 \cdot 4}\right)^2 \left(\frac{\text{vers } \theta}{2}\right)^2 + \text{\&c.} \right\} \sqrt{\frac{l}{g}};$$

where θ is half the angle through which the swing passes. When θ is very small, vers θ vanishes, and the swing is isochronous. If $\theta = 2°$, the error is about 1/13333, or two seconds in three days. If $\theta = 8°$, vers $\theta = 0·00973$, and the second and third terms become 0·00122 and 0·000003 respectively, or the time of oscillation is about 1/833 longer than it would be if the arc were indefinitely small.

Increase of temperature causes l to become longer, and therefore the clock to go more slowly. This cause of error is minimized by making the rod of some substance, such as varnished pine, which expands but little, or compensated for by some device, such as Graham's mercurial pendulum (1722), Harrison's gridiron pendulum (1725), or Baily's astronomical pendulum, in which expansion away from the axis of suspension is neutralized by an equal expansion towards it, so that the effective length of the pendulum remains unaltered.

The spring balance-wheel, which consists essentially of a heavy horizontal wheel, to which an oscillating motion is given by a long fine hair-spring, was invented by Hooke in 1660, and perfected by Huyghens in 1674. The difficulty of expansion is got over by dividing the wheel into two semicircles, each attached by one end only to the diameter, and made of two strips of metal of different coefficients of expansion, so that each curves inwards to compensate for the expansion of the radius which carries it.

Extremely short intervals of time have to be accurately measured in various scientific and practical researches, such as those connected with the science of astronomy and the art of gunnery. Many forms of the chronograph used for this purpose are extremely complicated, but the principle on which they all act is simple. A cylinder covered with paper is driven round by clockwork, at the rate, say, of a turn per minute, and a point connected with a pendulum beating half-seconds divides the circumference into 120 equal spaces. Suppose that by pressing a key an electric current causes a pen to press against the paper. So long as the key is down a line is traced, and the length of it, measured by the half-second pricks, determines how long the key has been down. Usually the cylinder is also caused to move along its axis, so as to throw the two circles of pricks and lines into spirals. It is said that 1/1000 of a second can be estimated by this method.

The need of accurate measures of time has had great effect upon, if it did not absolutely originate, the science of astronomy, and in many of the most important physical laws time is either directly or indirectly a most important factor. Thus, Sir William Thomson has found that, by a long-continued stress, the elastic resilience of a body may diminish, and has proposed for this curious fact the name of elastic fatigue; Harcourt and Esson and other chemists have investigated the circumstances which cause the rate at which certain chemical changes take place to vary; Berthelot and Dixon have measured the velocity of propagation of explosion waves; the time taken for sensation to pass through nerve-fibre and for other physiological phenomena has been carefully studied.

In 1830, Lyell, following up the work of Smith, Hutton, Murchison, and Sedgwick, showed that the history of the earth is continuous, and was governed by the same laws in the past as it is now, and hence that the rates at which changes are now going on are measures of the rates at which they have gone on in the past. Great doubt was thus thrown on the current view that the world has only existed for about 6000 years. For suppose chalk is now being formed at the bottom of the Atlantic at the rate of one-fifth of an inch per annum, and that the chalk formations in England, which are known to be more than 3500 feet thick, were formed in the same way at about the same rate; the time required for the mere formation of this series of beds would be, not 6000 years, but more nearly 3500 × 12 × 5, or 210,000 years! And we must reckon, in addition, the time required to form all the other beds below and above the chalk and to bring them all into their present positions and conditions.

Advanced geologists, then, convinced by the arguments of Lyell, postulated a world history of many millions of years, but their results were ignored or ridiculed by those who had not taken the trouble to investigate the proofs upon which the theory rested. In 1859, the publication of the "Origin of Species" brought this, among many other questions, prominently before the public. The admirable style and careful manner in which facts and theories, old and original, were shown by Darwin to point to the great law of evolution as opposed to the theory of special creations, threw what were previously the arcana of science open to all, and caused the acrimonious discussion of the duration, not only of each living or extinct type, but of the world itself. The fiercest conflict raged about the age of man, and evidence was gradually accumulated, which proved that for many thousand years the human type has been practically the same as it now is: the question then forced itself forward, How long would it take a simple cell to develop through various forms to the anthropoid apes and man? The answer was given in figures higher even than those required by the geologist.

On the other hand, the question of the possible age of the world in its present condition has been attacked by Sir William Thomson from the side of mathematical physics, and his results have been recalculated and extended by Profs. Tait and Darwin. Arguments based upon (1) the internal heat of the earth, (2) the retardation of the rotation of the earth due to tidal friction, (3) the temperature of the sun, seem to show that the earth has not continued under present conditions for more than from ten to a hundred millions of years; while the theory of evolution probably requires at least three hundred millions of years for even a comparatively brief portion of geological history. The two results, each supported by strong evidence, are at present in contradiction to each other.

Political economists have for some years past been gradually realizing the immense importance of time in all their theories and calculations. The various causes which accelerate and retard the rate of growth are most important questions, not only for agriculturists, but for the whole population, who are dependent for their subsistence upon the reproduction of plants and animals. As Malthus pointed out in 1798, the population of a civilized country increases in geometrical ratio, while the food-supply can only be increased by importation, by taking inferior land into cultivation, or by improved methods of production. The gradual advance of civilization tends to quicken the rate of increase of population, while it decreases the three palliatives; hence, at some time, a limit must be reached at which population will increase faster than the means of subsistence. The results of this condition of affairs have been most ably discussed by Mill, and will possibly, before long, be exemplified in England.

To an individual, all duration beyond comparatively few years is of no importance, but, to a country or corporation, the difference between a hundred years and perpetuity may be very great. Two instances of this distinction have recently caused some discussion. The services of a general or lawyer may be amply rewarded by the grant of an annuity for a hundred years or for three lives; while the burden of a "perpetual pension" is felt long after the services for which it is granted are forgotten, and too often after all who have any real claim upon, or connection with, the original recipient have passed away.

The old fiction of English law, that all the land of the country belongs to the Government, and that the holders of the land are in reality not owners, but tenants, has recently been brought into prominence by Mr. George and his followers. The tenure of land varies almost infinitely in different countries, and even in diffent parts of the same country, but two simple examples may serve to render the point at issue clear. In the United States the land in the Territories, speaking generally, belongs to the Government, and has been, and to some extent is being, sold to capitalists in large lots at "prairie value."

Suppose 1000 acres worth £1 an acre are sold outright, they would fetch £1000, but the present value of a lease for a hundred years, interest being reckoned at 4 per cent., is £980. So far as the capitalist is concerned, for all practical purposes, the land is as much his own in the second case as in the first, since any change would take place in the time of a descendant whom he has never seen, and a fair compensation might be arranged for any unexhausted improvements. But, from the point of view of the Government, the case is very different they would receive for the lease only £20 less than the selling price, and at the end of the century the land, with its "unearned increment," would revert to them in the same or better condition than it originally was, with the exception of minerals, for which special arrangements by royalty or otherwise must be made, and the conditions of the tenancy could then be altered to meet any change of circumstances. Where, as is generally the case in England, the land has long ago passed out of the possession of the community, considerations of public faith rightly overpower all considerations of expediency, but even in this case the absolute sale of "Crown lands" or "commons" seems to be suicidal. That things are not perfect is no reason for making them worse.

SYDNEY LUPTON.

NOTES.

WE print to-day an article on the proposal that English men of science and others should co-operate in the movement for the erection of a statue of Ohm in Munich. The Committee appointed by the meeting at the Royal Society to make the scheme known in England, and to collect subscriptions, consists of the following members:—Sir F. Abel, Prof. D. Atkinson, Mr. Vernon Boys, Mr. Conrad Cooke, Profs. Ewing, Fitzgerald, Fleming, G. Carey Foster, Mr. Glazebrook, Prof. D. E. Hughes, Mr. Norman Lockyer, Dr. Hugo Müller, Prof. John Perry, Mr. W. H. Preece, Lord Rayleigh, Profs. Reinold, Rücker, Stokes (President of the Royal Society), Mr. Swinburne, Sir William Thomson, and Prof. S. P. Thompson. Lord Rayleigh was elected President.

THE manuscript of the Royal Society Catalogue of Scientific Papers for the decade 1874–83 is now ready for the press, but Her Majesty's Government have informed the President and Council that it is not their intention to undertake, as in the case of previous decades, the printing and publication of the work.

THOSE who knew Dr. O. J. Broch, either when he was Professor of Mathematics at Christiania, or when he was Minister of the Board of Trade in Norway, or more recently, when he acted as Director of the International Bureau of Weights and Measures at Paris, and all who had any opportunity of intercourse with him either in social or official life, will hear of his death with deep regret. Dr. Broch died at Sèvres on the 5th inst., at the age of seventy-one. It has been the especial duty of the Bureau, over which Dr. Broch presided from its creation after the Metric Convention of 1875, to construct new standards of the metre and kilogramme for the different countries, including Great Britain, which were parties to that Convention. At the time of his death all these standards had been constructed, after much patient investigation, and were only awaiting final approval at Sevres, before their delivery this year to the several contracting States. Dr. Broch's work remains to us, not only in those standards of exact measurement which, with the assistance of the men of science attached to the Bureau, he so well designed and verified, but also in the various scientific contributions by which he advanced our knowledge, particularly those published annually by the Comité International des Poids et Mesures; and in the mathematical papers issued by the Academy of Sciences at Paris (Elliptic Functions, *Comptes rendus*, 1864, &c.). Dr. Broch was a corresponding member of the Paris Academy; he was also a member of the Academies of Sciences of Berlin and Copenhagen, and a high officer of the Legion of Honour of France, and of the Order of St. Olaf of Norway.

THE death is announced of M. G. Meninghini, who had been Professor of Geology at Pisa from 1849. He died, on January 29, at the age of seventy-eight.