channels, they and their flocks will be overtaken, though from opposite directions, by the inevitable Nemesis of disproportion."

A SEVENTH edition of "The London Catalogue of British Plants" has just been issued. The chief differences between this and the preceding edition is in a renumbering of the specific names, and in those changes of technical arrangement which have now rendered it necessary to abandon the original series of numbers. The first edition of 1844 was closely adapted to the "British Flora" of the late Sir Wm. Hooker. This seventh edition is made to correspond with the "English Botany" of Dr. Boswell-Syme, third edition, as far as to the grasses. For the ferns and allied orders, the arrangement and nomenclature of Dr. Hooker's "Student's Flora" are closely followed. The species of Chara are taken from Prof. Babington's "Manual of British Botany." Mr. Backhouse is followed in the species of Hieracium; Prof. Babington in the Rubi; Mr. Baker in Wild Roses.

THE *Gardener's Chronicle* quotes from the *Illustration Horticole* that the recent International Botanical Exhibition at Florence yielded a net profit of 1,000*l.*, and that the disposal of this sum to the best advantage of horticulture is under consideration.

A SCHOOL of Mines has been established by the Territorial Government at Golden, Colorado, one of the best places in the country for practical instruction.

THE Sixth Annual Report on the noxious, beneficial, and other insects of the State of Missouri has been issued.

MR. EDWARD BELLAMY, of the Charing Cross Hospital, has been appointed to deliver the course of lectures on the Anatomy of the Human Form, at the South Kensington Museum.

"ELEMENTARY Astronomy, or Notes and Questions on the Stars and Solar System" (Van Voorst), a small text-book for the use of schools, by C. C. Reeks, contains a great deal of recent and accurate information in small space, and seems calculated to serve the purpose for which it is intended.

THE additions to the Zoological Society's Gardens during the past week include an Australian Rail (*Rallus pectoralis*) from New Holland, presented by Mr. J. Harris; a Gannet (*Sula bassana*), European, presented by Mr. R. R. B. Norman; a White-winged Trumpeter (*Psophia leucoptera*) from S. America; a Dusky Monkey (*Semnopithecus obscurus*) from Malacca; a Pinche Monkey (*Midas œdipus*) from New Granada; a Bonnet Monkey (*Macacus radiatus*) from India, deposited.

*ON THE NECESSITY FOR PLACING PHYSICAL METEOROLOGY ON A RATIONAL BASIS.**

I WISH at the outset pointedly to disclaim originality in the main ideas to which I propose here to invite attention. The subject of my paper has occupied the thoughts of many men of science, with some of whom I have been in communication regarding it for several years. But though the conclusions to which I wish to lead you are the product of many minds, I am bound to accept to the fullest extent the self-imposed responsibility of bringing them forward at the present time and in the present form.

The branch of inquiry which has been very unsignificantly named Meteorology (meteoric phenomena being but slightly and remotely included in it) deals with the climate of the globe, and seeks to explain the vicissitudes of temperature and moisture, storm and calm, to which that globe is exposed. It is a subject of the highest importance to mankind generally, as affecting health, navigation, and agriculture; and possesses an interest acknowledged by every individual, from the savage to the *savant*, influencing as it does the personal well-being and daily comfort of all. Everyone discusses, and thinks himself competent to discuss, the weather.

* By Lieut.-Col. A. Strange, F.R.S., Inspector of Scientific Instruments to the Indian Government; a paper read at the British Association.

My present object necessitates a broad classification of this department of inquiry into two main branches. The more obvious one of these, for which a fitting name has yet to be proposed, relates to changes of weather from day to day, and to the varieties of climate found in different localities. I shall not say much on this branch of Meteorology, but shall confine myself principally to the other main division, which has been named—I believe, first by Prof. Balfour Stewart—Physical Meteorology. Under this term are included, amongst other important matters, fluctuations in the seasons; the causes, external to the earth, which occasion or contribute to them; and the laws which regulate these fluctuations. The opinion is daily gaining ground that this branch of Meteorology has been unduly neglected, that it offers a magnificent field of inquiry and discovery, and that its vigorous cultivation must greatly aid the solution of those more limited and local inquiries to which observation has been hitherto more particularly applied. My present object is to urge the cultivation of this wide and almost unoccupied field of research and to point out some of the steps which should now be taken to that end.

It will be necessary for my purpose first to advert to some of the most elementary facts connected with Meteorology. Speaking in general terms, there are but four principal elements concerned in the production of all meteorological phenomena—the familiar elements of antiquity—fire, water, earth, and air. The part played by each is obvious to every observer.

Water, sucked up by heat from the ocean, and from the land which has imbibed it, falls again from the clouds in the form of rain, undergoing alternately, through excess of heat, evaporation and condensation. *The earth*, a great recipient of both heat and moisture, gives up each gradually and silently, and helps to maintain equability of temperature and of humidity. *The air*, set in motion by heat locally applied, becomes breeze, or wind, or storm, according to the amount, duration, and locality of that heat. In each of these three cases we see that an external force, heat, plays a conspicuous part. Can either of the three named elements, Water, Earth, or Air, perform its functions without the aid of that external force? Have they any innate power, enabling them to act independently of each other, or of all external forces? Will water, if left to itself at an unchangeable temperature, rise into vapour and fall in rain? What power resides in the earth to cause meteorological phenomena? It may possibly be replied that it boasts volcanic power, but as this exists only locally, it can play but a small part in the great economy of the whole earth. The internal heat of the globe may also be claimed as an independent attribute of the earth, and it may be so—but on this question we have as yet but very little reliable knowledge, though much interesting speculation. It may, however, be stated that, as an explanation of leading meteorological phenomena, the internal heat of the globe has not as yet been allowed much, if any, weight, though its use as a modifier of such phenomena may be considerable. As to the air, no innate power has hitherto been assigned to it. We may therefore, without much risk of error, regard water, earth and air, for the purpose of the present inquiry, as three forms of inert matter, capable of exercising independently no force whatever, but when acted upon, either separately or in combination, by heat, capable of producing the most stupendous results.

We come now to this heat—the sun. Has this any innate power? It seems almost needless to answer the question. The most familiar occurrences attest his paramount influence: the alternations of day and night, the march of the seasons, the daily variations of warmth—all bear testimony to his all-pervading and tremendous power.

It might seem superfluous to state facts which are almost truisms. But would it not seem to follow as a matter of course, needless to dwell upon, that such being the paramount influence of the sun, its study must be the first and most anxious object of solicitude to the meteorologist? Yet such is not the case. Obvious as are the facts I have briefly indicated, they have led to no such result. The reports and volumes of observations emanating from bodies and institutions charged with meteorological researches often do not contain even the name of the sun, and it may be broadly stated that the great central source of heat, and therefore of all meteorological activity, receives little or no attention in that capacity. I do not prefer this as an indictment against those to whom I refer. Many reasons may be assigned for their total neglect of the sun. Perhaps amongst the most valid is the fact that instrumental appliances fitted for the purpose have not, until within a comparatively recent period, existed.

Another powerful reason no doubt is to be found in the difficulty with which even cultivated scientific minds can be brought to recognise, as a truth to be practically acted on, that no science stands alone, that all are intimately connected by nature, and that the classification and separation of various branches of inquiry is an artificial arrangement of man, adopted for the more convenient division of labour.

The time seems to have arrived when we ought to apply this truth to the science of meteorology, and to bring to its aid a class of researches calculated to provide it with that secure and rational basis of which at present it is absolutely destitute.

Before passing to a consideration of the steps which seem necessary to this end, I will touch slightly on one of the objects the hope to attain which fully justifies their being taken. I allude to the hope that we may thereby find some explanation and some law for the fluctuations of the seasons.

In a given locality, on a given date, the sun, to whom we ascribe so predominating an influence, attains, year after year, the same elevation above the horizon, and being at the same distance, presents the same angular area. If the sun, as that date annually recurs, were in all other respects the same, we should have a right to expect an annual recurrence of the same weather, unless some disturbing cause, of which we have at present no knowledge, were known to exist. I do not say positively that the sun being a constant force, we should have this constancy in the seasons—but what I do say is, that if the sun be not a constant force, we have no right to expect constancy in the seasons. The first question, therefore, should be: Is the sun a constant force? Does it, year after year, at the same date, present the same unvaried surface? We know that the contrary is the case.

We know that the surface of the sun's disc is never free from spots, and that these spots are constantly changing in number, size, and position: we know that whatever law may govern them, their period of change and return is certainly not annual.

We know also that the general surface of the sun is covered with markings called faculæ, which are perpetually changing, and which have not an annual period. We have also learnt, within two or three years, by the aid of the spectroscope, how at any time to examine the exterior gaseous envelope of the sun, which formerly could only be seen during a total eclipse, and we now know that the famous red prominences of which on those rare occasions we obtained only a fleeting glimpse, on being studied at our ease, without interruption, reveal evidence of activity in those regions of the most stupendous sublimity, darting out, in a few seconds, flames many thousands of miles in extent. Further, in examining the spectrum of the solar light with improved spectroscopes assisted by photography, we find that thousands of lines exist there of which hitherto we had no knowledge—and quite recently the researches of Norman Lockyer tend to throw a doubt on the fixity and constancy of some of these lines.

We have here evidence which conclusively proves that the sun's surface and surroundings are not maintained in a constant condition. The evidence may not justify us in asserting that as his surface changes so must the force which he pours out on the earth necessarily change also; but it certainly justifies us in entering on a systematic examination of that question with the appliances which modern physical astronomers have contrived for the purpose.

In what, then, should this systematic study of the sun consist? Up to the present time the spots have been the main object of study. Most valuable observations on these have been made, of which those of Carrington, of Howlett, of Selwyn, and of the Kew Observatory under the auspices and direction of Warren De la Rue and Balfour Stewart, may be mentioned as the most complete and most long-continued. But excellent as these series are, and great as is their value, this consists chiefly in their having shown the extent and character of the work that has to be done. They labour under the unavoidable defect of frequent interruption by cloudy weather—about two-thirds of the year are thus lost in England, and the evidence afforded by the remaining one-third is diminished in value. But even some of these researches have now been discontinued—in the case of Kew, for want of the requisite funds.

The conclusion arrived at by those who have devoted themselves to the subject is that *a daily record* of the changes taking place on the sun's surface is necessary. I will here advert only to the changes in the spots. These we already know do not take place arbitrarily: they gradually increase in aggregate area to a maximum, and as gradually decrease to a minimum—their period having been provisionally fixed at about 11½ years. But this period has been derived from observations of all the spots visible, without discrimination—and the "spotted area" is the aggregate area of all such spots. There is, however, reason to suspect that if it were possible to trace each individual spot throughout its existence, from its first formation to its final disappearance, there would be found to be different classes of spots having very different durations and perhaps very different maximum and minimum periods; and a reduction of these classes separately might, and probably would, result in a considerable modification of of the present 11½ years cycle, and possibly in the discovery of other cycles, at present masked in the period determined from all spots taken indiscriminately. But hitherto the absence of anything approaching a daily record of the spots has precluded any attempt to classify them. What is true of the spots is also probably true of all other manifestations of solar energy.

With respect to sun-spot researches, it fortunately happens that the photographic records need not be all taken at the same station. The record of one day taken in England can be combined with the record of the next day taken at the other side of the globe. Hence, in order to obtain this daily record it is only necessary to select a certain number of stations in localities such that there shall always be clear weather at one of them. India offers peculiar facilities for such a selection of stations, owing to the great variety of climate to be found in that country during the same period of the year. Perhaps four or five such stations would suffice for India, and if absolute continuity of record could not be obtained by them, the deficiencies could easily be made good by stations in our colonial possessions.

I think it hardly necessary that I should state that in advocating this system of continuous solar record I do not intend that other methods of meteorological research, now in use, should be abandoned. It is obvious that both methods must be employed. Whether present methods do not admit of considerable extension and improvement, is a very important question, on which, however, I do not here propose to enter. Nor do I intend to discuss the question whether the sun stations now advocated should not also be meteorological stations in the ordinary sense. This, like many other such questions which will have to be settled, is an administrative detail, which I shall not step aside from the consideration of fundamental principles to discuss.

It is scarcely necessary to point out that such a system of daily solar record as I have indicated is beyond the reach of individuals, and must, if attempted at all, be established and maintained by the State. The degree and direction in which the State should aid the advancement of science has been much debated of late, and the British Association has contributed powerfully, by obtaining a Royal Commission presided over by the Duke of Devonshire, to the solution of this difficult problem. As I have taken a part in these discussions, and have given considerable attention to the subject, I may perhaps, without impropriety, here state what appear to be the principles applicable to the particular case we are now concerned with.

The first principle is that private enterprise should not only be allowed the most perfect freedom from interference or competition by the State, but that it should be encouraged and aided in every possible way.

The second principle is that the State should step in where private enterprise fails, and itself conduct scientific research, whether observational or experimental, subject to the following main conditions:—

(*a*) That the probable results of the research will be beneficial, in the widest sense of that term, to the community at large, or to the various departments of the State.

(*b*) That the research is too costly, or commercially too unremunerative, to be undertaken and vigorously prosecuted by individuals.

(*c*) That the research requires continuous uninterrupted work extending over very long periods, and conducted by systematically organised establishments.

Probably no case could be mentioned as so completely satisfying these three conditions as that of researches affecting closely every interest in the community, needing for their conduct a number of well-equipped establishments, maintained, not merely for many years, but certainly for generations—possibly for centuries. This is work which it is futile to demand from individuals.

I wish to guard against being thought to assert that the study of the sun will certainly solve all the enigmas of meteorology. I do assert that the strongest possible *primâ facie* has been made out against the sun as the principal ringleader in meteorological

agitation—and that there are ample grounds for putting him on his trial. Let us however suppose the impossible case of his absolute acquittal, I maintain that this negative result would be worth all the labour of obtaining it—eliminating, as it would do, one, and that the most conspicuous of probable causes, and so narrowing our inquiries to those that remain. The more likely event, however, will be that whilst the sun will be proved to be the chief promoter of these disturbances, his accomplices, and their various degrees of participation, will be dragged more prominently before the light.

Nor do I desire that the "innate power" I have attributed to the sun, and denied to other elements, should be misunderstood. I have used the term as the only one available to mark strongly the relative influences at work. I by no means intend to use the word "*innate*" in an absolute sense, or even to imply that the forces of the sun are self- enerated and self-maintained. The object of this paper is a strictly practical one, and is not to be taken as intended to contribute one word to speculations on the constitution of the sun. But though disclaiming speculation, I may, on behalf of my practical object, point out that we already possess what may at least be claimed to be presumptive evidence that the sun is not exempt from external influences. I allude to the remarkable apparent connection which the researches of De la Rue, Stewart, and Loewy have established between the behaviour of the sun-spots and the positions of some of the planets, particularly Venus, the Earth, and Jupiter. I say that the mention of a result so well calculated to excite speculation, aids my practical object. I mean that by following up the hint given us by these most remarkable researches, we may be led to a more complete knowledge and more philosophical conception of the structure of the universe.

And I would here remark that I have urged the study of the sun from the meteorological point of view in order to give a practical justification for the adoption of definite practical steps. But that study is recommended by even higher considerations still, by the insight it must give us into cosmical relations, and the help it will afford us in seeking to understand something, if not of first causes, at least of causes of the highest order that our limited intelligence can grasp and reason on.

The more one reflects on the neglect of the sun justly chargeable against us, the more one wonders at it. It is like the case of a man placed before a steam-engine for the first time, and seeking to learn its principle and action by counting and measuring the bolts, screws, and rods, without giving a moment's attention to the source of power—the furnace and boiler. What they are to the steam-engine the sun is to us, and it is astounding that men should dare to undertake a solution of the complex and mysterious fabric which surrounds us without giving a foremost place in their investigations to the source of all material life and power.

Civilisation has been variously described and defined. It seems to me to imply above all things *completeness*. It aims at supplying all wants, at removing all obstacles to thought and to action, at making good all deficiencies, at remedying all evils moral and material, at guarding against all dangers, at promoting all beneficence, at extending and perfecting all knowledge. Science, as the most potent guide and instrument of civilisation, needs also to be complete. A harp with broken strings can discourse no music,—a chain with unconnected links can sustain no weight. Science, as our President so eloquently impressed upon us in the address with which he opened this Section, is one and indivisible. It has been broken up by man into its various recognised branches to serve his convenience and to assist the weakness of his intelligence; but nothing, as the same authority told us, is more subversive of truth and more hindering to progress than to regard these subdivisions as representing the actual order of nature. There must be doors of communication between the observatory, the laboratory, and the mathematician's study. The isolation of particular fields of research is no longer tolerable: each passes, however indirectly and insensibly, into the other through that "border land" which, as our President reminded us, "recent investigation has shown to be so fertile of discovery."

The study of the sun stands on this "border land." It belongs but very partially to the domain of the ancient astronomy, it possesses some holding in the provinces of chemistry and geology, and more still in that of physics, it claims as its right (as what branch of science does not?) the devotion of the mathematician, and it rules almost supreme in meteorology.

This study asks to be recognised and provided for. How much longer will the demand be disregarded?

*IN WHAT WAY AND AT WHAT STAGE CAN TECHNICAL INSTRUCTION BE BEST INTRODUCED INTO OUR SYSTEM OF NATIONAL EDUCATION**

IT will simplify the consideration of the subject, the discussion of which I have been requested to introduce, if we admit frankly that in England at any rate (I am glad to believe that Scotland is more fortunate) we do not possess a system of national education. Such a system, as I conceive it, should afford to all the children of the nation adequate elementary instruction, and, moreover, should offer to all, so far as their capacities and other circumstances will enable them to take advantage of it, full opportunity for further mental cultivation. There are lying before me the calendars of two German schools for boys of the middle class intended for a mercantile or industrial career: the Friedrich-Werder Gewerbe, or Trade School of Berlin, and the Real Schule, under the direction of Dr. Schellen at Cologne. The courses of each of these institutions following after some preparatory teaching in an elementary school or at home, where reading and writing together with a little arithmetic have been acquired, retain their pupils during nine or ten years; and boys who, according to the reports, were to become mechanical engineers, builders, postmasters, merchants, and chemists, left those schools last July, having attained the ages of seventeen to twenty years. The Real Schule of Cologne, the average number of whose pupils is 580, has 28 masters; the Gewerbe Schule of Berlin, averaging 540, has a staff of 32 masters. In every German town of the least importance there are, in addition to the Gymnasium or Classical School, one or more technical schools resembling those of Berlin and Cologne; the numerous Universities and Polytechnic Institutions furnish the requisite staff of teachers. The fees are small. I have no information as to those of the schools which I have quoted, but I find from the prospectus of another very celebrated trade school, that of Barmen in Westphalia, that its school fees for the year are from 3*l.* in the lowest to 6*l.* in the highest class, and that boys whose friends do not reside in the town are boarded for 25*l.* The governments, the municipalities, and private persons vie with each other in placing at the disposal of poor scholars of the elementary schools who have shown superior capacity, the means of continuing their studies in these secondary schools.

I need not describe the elementary schools of Germany and Switzerland; it is now well known that, in them, the children of the poor receive, up to the age of fourteen years, sound elementary instruction, not confined to reading, writing, and arithmetic, but including geography, the outlines of the history of their own and other European countries, a modern language, some elementary teaching in science, and instruction in the religion which their parents acknowledge.

As contrasted with a system of education such as I have referred to and excluding the great public schools, available only to the rich, we have in England for the middle classes schools like those attached to King's and University Colleges, the City of London School, the Bristol Trades School, and, thanks to the Endowed Schools Commissioners, a few efficient or at any rate progressive grammar and endowed schools, amongst which I would more particularly name the school at Giggleswick, near Skipton, as one where instruction in science has been included in the general plan of instruction; and a small number of exceptional private schools in which a praiseworthy attempt is made to adapt the instruction to the requirements of industrial and commercial classes. These schools however rarely retain their pupils beyond the age of fifteen to seventeen years, and when all are reckoned they are utterly inadequate to the wants of the population.

Of elementary school buildings we shall soon have a sufficient number, and it is probable that the duty of the parent to send his child to school will, in some way or other, be in all cases made a legal obligation; but so long as the necessity of rendering our training schools for elementary teachers thoroughly national and efficient is not acknowledged, and so long as the instruction of the children in elementary schools is left in a great measure to the care of other ill-taught children, called pupil-teachers, of from thirteen to seventeen years of age, we cannot hope that our poor will receive proper elementary instruction.

Until the English approach the German schools in number and value it would be vain to expect that technical instruction will be universally accessible, and we can only hope for its gradual

* A paper read before the Social Science Association, Oct. 1, by Mr. B. Samuelson, M.P.