At one time—as, for example, in the early days of the Royal Society—it was possible for every member of a general scientific society to take an intelligent interest in every paper presented. Since then, however, science has passed from the stage of a simple organism to that of a body made up of parts with highly differentiated functions. Numerous specialised scientific societies have been formed, as may be seen by the list published in this issue of those established since 1869, and many periodicals similarly devoted to distinct branches of pure and applied science have come into existence. The common factor is interest in the advancement of knowledge; and a society or a journal concerned with this as a whole can best assist the aim in general by providing the segregated groups of investigators with intelligible accounts of activities in other fields, which may or may not be on the borders of their own.

The remarkable collection of articles published in this issue represents the highest type of contributions of this kind. Each article is by an eminent authority upon the subject with which it deals, and each can be comprehended by everyone who has had a scientific training. It is scarcely too much to say that no such authoritative epitome of fifty years of scientific progress, as viewed by pioneers in particular fields, has ever been brought together in any one periodical. Contributions of such high distinction are rendered possible largely because the writers know that in these pages they are addressing themselves to fellow-workers throughout the world, as well as to other readers having an intelligent interest in the march of scientific knowledge.

Four of the writers—Sir Archibald Geikie, Sir E. Ray Lankester, Prof. Bonney, and Canon Wilson—were contributors to the earliest issues of this journal; and every reader will be grateful for the enlightening descriptions of stepping-stones of scientific progress which we are now privileged to publish. NATURE could not have maintained its original standard for so long but for the active support which these and many other leading men of science have been ready to give it since its foundation. This is as true of the new generation as it was when the journal was founded; and the value of the association is most highly appreciated. While NATURE is honoured by the active co-operation of the men of genius who are traversing the royal roads of science, its functions will extend, and its influence increase, with the expansion of knowledge. With this assurance, and the encouragement which the past has given, we look with confidence and strength at the prospect of the future.

## SCIENTIFIC WORTHIES.

### XLI.—SIR NORMAN LOCKYER, K.C.B., F.R.S.

THE simple title NATURE, embracing all in a single word, was most appropriately chosen by Sir Norman Lockyer when, exactly fifty years ago, he founded this weekly journal, which is devoted to all the sciences, and has had so successful a career. The first article in the journal reproduced profound aphorisms of Goethe on the intimate relations of man with Nature, of which he is a part. The poet-philosopher set forth in striking language, which was rendered into English by Huxley, the innate feebleness of man before the immutable forces and the great mysteries which everywhere surround him, and at the same time the incessant human desire, never completely satisfied, of comprehending and penetrating them. The contribution is a stimulating preface to a scientific periodical; it well exhibits the high character of the journal at the outset, and the spirit in which it has always been conducted.

Indeed, NATURE is, of all scientific journals, the most comprehensive in the world; it includes articles of the highest scientific standard, as well as those of a more popular kind; it has open columns for the discussion of current subjects, and it provides summaries of most of the papers presented to the chief academies and learned societies; it gives the latest events of the scientific world, news about men of science, and accounts of the most recent discoveries in scientific fields. It has rendered inestimable services to the cause of science in general.

Since the first issue the journal has maintained the form and character which we see to-day. A comparison of a number issued in the year 1869 with one of 1919 shows the same general arrangement, the same sequence of subject-matter; moreover, the pages and the style of type are nearly identical in appearance. The founder, who in 1869 was only thirty-three years of age, has proved himself a publicist and an organiser of the first rank. During its existence the journal has ably recorded the magnificent discoveries which have distinguished the last fifty years in every branch of science; it has had to deal with subjects beyond one's dreams; and it has been the better able to present them to the public because the founder has himself been one of the foremost builders of this noble edifice.

Sir Norman Lockyer is distinguished not only by his eminent public work, but also as one of the greatest men of science of our time. In the three years which preceded the foundation of this journal he made discoveries relating to the sun which will permanently preserve his memory

among men. He was one of the pioneers of astrophysics, the new branch of astronomy which is now of such importance. For fifty years, with untiring activity, he has carried on a multitude of researches in the three observatories established by him and in the physical laboratories associated with them; and, like a true philosopher, he has presented a general synthesis of celestial phenomena. The title "Nature" might be justly given to the record of his personal achievements, to which the remarks which follow are particularly devoted.

Sir Norman Lockyer is not the product of a university; he may be termed a self-made man of science. He was at first employed in a Government Department, where he remained for more than ten years; but he was irresistibly drawn towards science, and especially to astronomy, the wonder of which exercises a powerful attraction. All his leisure and all his personal resources were devoted to scientific pursuits. Spectrum analysis had come into being, and its application to celestial bodies opened up the widest horizons. Sir Norman Lockyer attached a small spectroscope to a modest equatorial telescope of 6-in. aperture, which constituted his private observatory, and he studied the light emanating from the solar spots. The first results were summarised in a note presented to the Royal Society in 1866, where the author discussed the bearing of his observations on the two rival theories which were then to the front as to the nature of sun-spots. He foresaw the possible daily observation of the red flames, or prominences, which up to that time had only been observed on the outer edges of the sun during total eclipses. He conceived the idea that the spectroscope might be able to reveal them at ordinary times under the same conditions as those which caused the appearance of bright lines in the new star in Corona Borealis. This star had appeared a few months previously, and, as observed by Huggins, had presented a stellar nucleus surrounded by a relatively feeble nebulosity; but in the spectroscope the light of the nucleus was spread out in a continuous spectrum and thereby enfeebled, while the atmosphere showed the bright lines of hydrogen with great brilliance.

This idea was really a flash of genius, because it contained the germ, or the principle, of the method which, for fifty years, has revealed to us at all hours of the day the gaseous atmosphere of the sun. The first application of the method to the sun's edge, however, gave no result; the spectroscope employed was not sufficiently powerful. Two years later the observations in India of the total eclipse of the sun of August, 1868, gave valuable information—the solar prominences were gaseous, and showed the red and green lines of hydrogen with very great intensity.

On October 20, 1868, Sir Norman Lockyer, at last provided with a powerful spectroscope, for which he had waited two years, discovered, at Hampstead, a prominence on the sun's edge, and made a drawing of it two days later. The discovery was communicated to the Royal Society on October 20 and to the Academy of Sciences at Paris on October 26. By a striking coincidence, at the same meeting of the Academy, a letter sent from India by the French astronomer Janssen announced the same result. During the eclipse Janssen had recognised in the spectroscope the nature of the prominences, and was able to see them again on the following day with the same instrument. Janssen continued to observe them daily during three weeks, and found that they were composed principally of hydrogen, and were subject to remarkable variations of form which were often very rapid. The astronomer Faye then pointed out that the first idea of the method was certainly due to Lockyer, but that the first application had been realised by Janssen, and since then the two names have been justly united in connection with the discovery.

During the weeks and months which followed, Sir Norman, with praiseworthy activity, continued the study of the sun by the new method without intermission, and he successively recognised several new facts of the first importance, namely:—

1. The prominences emanate from a gaseous layer of the same composition, which envelops the entire sun, and reaches a height of 8–10 secs. of arc. This layer is of a rose colour, like that of the prominences themselves, and Sir Norman Lockyer gave it the name of the *chromosphere*; it had already been glimpsed in preceding eclipses, but its existence was not generally acknowledged.

2. The yellow radiation of the prominences, which had been attributed to sodium by the eclipse observers, proclaimed in reality the existence of a new gas, to which Sir Norman gave the name of *helium*. It was the first recognition of the famous gas which was afterwards obtained from terrestrial sources by Ramsay in 1898; it is emitted by radio-active bodies, and now can be used for the inflation of dirigibles.

3. The green line of hydrogen becomes broader in passing from the summit to the base of a prominence. From a series of experiments on hydrogen at low pressures, carried on in the chemical laboratory of his friend, Frankland, Sir Norman concluded that this widening is simply due

to an increase of pressure. Spectrum analysis disclosed not only the chemical composition of the prominences, but also to a certain extent their physical state.

4. The lines of the prominences are often displaced and distorted. This phenomenon was correctly attributed to the movements of the vapour in the direction of the observer; it was the first real verification of the velocity displacements which have since become of such great importance in astronomy.

This first series of investigations is set forth in some detail, because it represents magnificent work; it is an example for all, and has its place marked out in the history of science, especially as it was carried out with simple means. The greatest discoveries, as one knows, have not been made in the largest laboratories, and the capacity of the man is always of more consequence in research than that of his instruments. In his investigations Sir Norman Lockyer has shown a power, an acuteness of mind, and a creative imagination which are truly exceptional. These are the qualities of men who, like him, have overcome all difficulties placed in their way in order to pursue fixed ideas and follow vocations which they have fully resolved to adopt.

In the succeeding years Sir Norman organised several eclipse expeditions under Government auspices; all the important solar eclipses since 1868 have been observed by him or by his assistants, with programmes laid down by the Solar Physics Committee, of which he was a member. At the same time, he undertook extensive work which may be summarised in the words: "Comparative study of terrestrial spectra and the spectrum of the sun, extended afterwards to stars, nebulæ, and comets. Special and general consequences drawn from them." After fifty years of continuous labour the work has certainly been advanced, but it is not yet completed. It was carried on at first in his own observatory, then from 1879 in the establishment at South Kensington which the Government had created for the development of the new methods and placed under his direction.

The astrophysical observatory at South Kensington was a model of its kind; it consisted of two parts, quite distinct but closely related, namely, an observatory properly so called and a physical laboratory. The astrophysicist must pass constantly from one to the other, and, in fact, the number of publications issued from South Kensington has been nearly the same in the two sections. It has been said that an astrophysical observatory is merely a physical laboratory oriented towards astronomy, the astronomical instruments being in reality nothing more than physical apparatus of large dimensions; and it is therefore necessary to attach to them men who have been trained by the study of physics and capable of immediately applying to the celestial bodies the most recent discoveries made in the laboratory.

In this connection Sir Norman has trained at South Kensington several investigators, including Prof. Fowler, Dr. Lockyer, and Messrs. Shackleton, Baxandall, and Butler, at once physicists and astronomers, and well known by their publications. Prof. Fowler, now president of the Royal Astronomical Society, is already distinguished; we owe to him important discoveries and some fine series of precise measurements.

In 1912 the land occupied by the observatory at South Kensington was required for the extension of the Science Museum, and the observatory, with all its instruments, was transferred to Cambridge. Sir Norman, having passed the age-limit, was obliged to retire from the directorship, but, feeling that his work was not yet accomplished, and still vigorous in body and mind, he forthwith set up another observatory—the Hill Observatory—with the aid of several friends of science. The site chosen, at Sidmouth, is very favourable for astronomical observations, and as the first buildings were erected very quickly and provided immediately with some fine instruments, the researches commenced at South Kensington, especially those on stellar spectra, have been continued with but little interruption. It is hoped to establish there an astrophysical observatory comparable with the American observatories and worthy of the United Kingdom.

The new facts gathered together in the course of these fifty years are extremely numerous; they are set forth with the inferences drawn from them in 200 memoirs, and it is impossible to give any detailed analysis of them here. Fortunately, the author, who has an affection for great generalisations, has always sought to connect the facts in a few leading ideas which are for him "working hypotheses," and he has expounded each hypothesis in a special book. The volume on "The Chemistry of the Sun" (1887) deals with the differences of spectrum emitted by different parts of the sun, and explains them by the dissociation hypothesis, according to which the molecules and atoms are grouped in different ways or are split up into simpler elements. In his book on "The Meteoritic Hypothesis" (1890) the author explains all the celestial bodies by collisions of meteorites; it is a simple and fertile idea, which has been

adopted by several astronomers. The last volume, entitled "Inorganic Evolution" (1900), develops the final methods and ideas of the author, and presents a general classification of all the stars. It is only necessary to add one remark: Sir Norman is one of those who publish the observed facts immediately, and also the interpretations which present themselves at once to his mind. This method inevitably involves imperfect detail, or over-sanguine conclusions, which have been freely criticised. Pruning and revision have become necessary, and this work has recently been taken in hand by the author himself. The main body of facts and ideas remains unaffected, and is always worthy of being retained.

It will suffice to mention here very briefly on one part some of the more important results on the sun and the effects of its radiation, and, on the other, the great classification of the stars.

Sir Norman was the first to recognise the presence in the solar spectrum of lines due to a band spectrum, attributed at first to cyanogen, and now assigned to nitrogen alone. He observed the widening of the dark lines in the spectra of sun-spots, a phenomenon which has since been so brilliantly explained by Prof. Hale, of the Mount Wilson Observatory.

With the simple arrangement of the objective prism, he was the first to photograph in an eclipse the spectrum of bright lines given by the reversing layer, situated at the base of the chromosphere, thus obtaining a verification of the general accordance of these bright lines with the ordinary dark lines, and confirming the simple explanation of the dark lines given by Kirchhoff.

He discovered in the fluctuations of the solar prominences a period of 3·8 years, which is superposed on the great eleven-yearly period, and he showed later, in collaboration with Dr. Lockyer, that this same period of 3·8 years reveals itself in variations of pressure of the terrestrial atmosphere. This last result has a practical importance because it renders possible the forecasting of the variations of the monsoons in the Indian Ocean. In addition, the schematic chart of the law of the winds in the southern hemisphere, drawn up in this case by Dr. Lockyer, has been verified by all later observations; it has been reannounced in 1919 by Prof. Hildebrandson, one of the founders of meteorology, in a note on the general movements of the atmosphere presented to the Paris Academy of Sciences.

One of the questions which have most occupied Sir Norman is that of the variation of laboratory spectra with the energy of the excitation. He has from the first distinguished the long and short lines in the same spectrum, and the employment of a very powerful induction spark has given him new lines which he has called "enhanced lines." The three types of lines—long, short, and enhanced—correspond with increasing temperature, and constitute valuable tests which serve to differentiate the stars. Sir Norman has observed the presence of these lines in the spectra of stars, and at the same time the different behaviour of the lines of hydrogen, of helium, and of the metals, which has led to a new classification of the stars. The labour involved in this investigation was considerable, because it became necessary to photograph stellar spectra under the unfavourable conditions of London and with a high dispersion. Its success was secured by the use of an objective prism of large angle and by great patience.

At the same time, the great American astronomer Pickering, with much more powerful means, had entered upon the observation and classification of stellar spectra over the entire sky, and was content to use a small dispersion which enabled him to reach the fainter stars. But as the study of enhanced lines demanded a high dispersion, Sir Norman confined himself to the stars visible to the naked eye.

The classification adopted differs essentially from all previous classifications, which had considered only the actual temperatures of the stars and supposed a continuous cooling. Sir Norman went much further, and in the year 1888 established a distinction between the stars in which the temperature was rising, and those in which the temperature was diminishing. Beginning with a primitive nebula, the body which forms by condensation will at first become hotter, then attain a stationary temperature, and will finally cool. Its natural evolution, expressed by temperature as a function of time, ought to comprise an ascending branch, a steady state corresponding with the maximum, and a descending branch. In the ascending phase the lines of hydrogen are narrow and the chromosphere is of low density; at the time of maximum the enhanced lines predominate and the maximum intensity of the spectrum is far in the ultra-violet; in the later phase the lines of hydrogen are broad and diffuse, and the chromosphere is of greater density. It is certain that one thus penetrates more deeply into the nature of things. Further, Sir Norman does not explain the variable number of metallic lines by a different distribution of the chemical elements in the stellar atmosphere. When the star is very hot the metallic lines are wanting, and he has attributed this to a dissocia-

tion of the elements analogous to that of radio-active bodies. On this view the heavier elements are split up into lighter and even into new and simpler elements which he has called "proto-elements." The evolution of the stars is accompanied by a simultaneous evolution of the simple elements of Nature.

The great chemist, Ramsay, who was a pioneer in many directions, gave the greatest attention to these new ideas and to the numerous observations which appeared to support them. The classification of the stars in accordance with the foregoing tests has been fully confirmed by optical measurements of their absolute temperatures.

To sum up, in his latest researches, as well as in the first, Sir Norman Lockyer has exhibited an aptitude for experiment, a creative faculty, a penetration, and a breadth of view which are truly remarkable; and the results obtained on the sole basis of experiment are of the first importance. He is one of the great men of science of England and one of the greatest astronomers of all time. Finally, let us hope that, bearing the weight of years in comfort, he may continue his services to science and his association with this journal, and witness for himself the increasing success of his ideas and his methods.

H. DESLANDRES.
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# RETROSPECT AND PROSPECT.

BY SIR ARCHIBALD GEIKIE, O.M., K.C.B., F.R.S.

FIFTY years have passed since the publication of the first number of NATURE on November 4, 1869. To start successfully a weekly journal entirely devoted to chronicling the onward march of science was an experiment that could not but involve some financial risk, and certainly required no small editorial ability. To maintain such a journal for half a century on a high level of excellence, and to gain for it a place admittedly of importance in the periodical literature of our time, is a feat of which Editor and publishers have good reason to be proud. The weekly contributions of this journal to current scientific literature now amount altogether to more than a hundred volumes, which contain a contemporary record of the progress made by every department of natural knowledge, often contributed by the men to whom the progress was due. It may be appropriate, as we take note of this achievement, to cast an eye back upon the condition of science among us fifty years ago, to survey our present position, and to look forward into the vista that is opening out for the future.

In taking such a retrospect one of the most conspicuous and satisfactory features to attract attention is the remarkable increase and steady growth of fresh centres of higher education all over Britain, where not only is the time-honoured literary side cherished, but ample room and full equipment are found for the theoretical and practical teaching of science. These centres, beginning perhaps as modest colleges, have attracted a constantly increasing number of students, and each of them has become a nursery in which the men of science of the future are being bred. A convincing proof of their vitality is furnished by their successful claim for recognition as universities. They have already added half a dozen new universities to our educational strength, and this year one of the youngest yet most important of them, the Imperial College of Science and Technology, is now in turn demanding the status and powers of a university. There has never been a time in our history when the opportunities for obtaining a thorough scientific training have been thrown open so widely and attractively, and when advantage has been taken of them in so large a measure.

That one of the great duties of a nation is to promote the cultivation of science by appropriating funds not only in aid of education in theory and practice, but also in support of research and experiment, never began to be realised until within living memory. British science has attained its greatness without State aid. There are, indeed, a few directions in which public money has been disbursed for scientific objects, such, for instance, as Greenwich Observatory, the British Museum, and the various geographical expeditions and geological surveys. But not until the middle of last century did it dawn upon the attention of the Ministry of the day, awakened possibly by the portents of the coming Great Exhibition of 1851, that men of science are not as a rule wealthy, that they must often be involved in considerable expense in carrying on their researches, that they cannot always look to the universities, colleges, or learned societies for financial support, and therefore that it might be of public advantage to come to their help from the public purse. Accordingly, in November, 1849, Lord John Russell, then Prime Minister, sent a confidential communication on the subject to the president of the Royal Society (Earl of Rosse), who remitted to a committee to report how a financial grant, if made by Government, could best be employed.

After deliberate Governmental consideration for the space of nearly a year it was decided at the beginning of 1851 to make an annual grant of one thousand pounds to be administered by the Royal