distinct to show that it was due to uranous oxide. Though the presence of zirconia prevented solution by pure carbonate of soda, the addition of a little borax enabled me to prove that uranic oxide is really present in some jargons. Such then being the case, it seemed desirable to ascertain whether the oxides of uranium would give rise to any special spectra when present along with zirconia in crystalline blowpipe-beads. To my astonishment I found that the spectra were precisely the same as those obtained in the case of what I had thought to be an approximately pure new earth.* Hence the very abnormal spectra, which seemed sufficient to establish the existence of a new earth, are really due to compounds of zirconia with the oxides of uranium, which have such a powerful action on light, that an almost inappreciable amount is sufficient to produce the spectra to great perfection—in fact so small an amount, that the total quantity which misled me was only a few thousandths of a grain; and its presence might easily have remained unsuspected, if I had not discovered the carbonate of soda test just named. In the case of transparent blowpipe-beads of borax with microcosmic salt, it is requisite to have as much as about $\frac{1}{60}$ grain of uranous oxide to show faintly the characteristic absorption-bands, whereas, when present along with zirconia in the crystalline beads, $\frac{1}{6000}$ grain gives an equally well-marked spectrum; and $\frac{1}{2000}$ grain shows it far better than a larger quantity, which makes the beads too opaque. These very minute quantities were obtained by the repeated division of a small known weight, either before or after fusion with borax. This spectrum also differs very considerably from the spectra of the usual salts or blowpipe-beads of uranous oxide. On comparing them side by side, the only common peculiarity is the fact of there being numerous absorption-bands distributed over a large part of the spectrum; but they do not correspond in either number or position. On the contrary, they differ almost as much as possible; and the darker bands in the spectrum of this zirconia compound occur where the transmitted light is the brightest in other cases. One of the most striking peculiarities of the spectrum of some jargons is, that when light passes in a direction perpendicular to the principal axis of the crystal, and the spectrum is divided by means of a double-image prism into two spectra, having the light polarised in opposite planes, though some of the absorption-bands are of equal intensity in both images, yet others are comparatively absent, some in one and some in the other; whereas, in the case of other dichroic crystals, all the absorption-bands are usually more distinct in one image, and fainter, or even comparatively absent, in the other. The general character of the spectrum was entirely unlike that of all the known compounds of uranic oxide. Instead of the moderately broad absorption-bands in the blue end, ignited jargons give a most unusually large number of narrow black lines, extending from the red end, so that nearly all occur in that part of the spectrum which is entirely free from bands in all previously known compounds of uranic oxide. Besides uranium, and several of the more common earths and oxides, I have detected in some zircons erbium, didymium, yttria, and another substance which exists in such small quantity that I have not yet been able to ascertain whether or no it is the suspected new earth. These accidental constituents do not indeed occur in sufficient quantity to be of importance, except as modifying the physical and optical properties, the didymium giving the usual characteristic absorption-bands (zircons from Sveneroe, Norway), and the manganese, the same spectrum as that of garnets (zircons from an unknown locality in Siberia†). The oxide of uranium is so easily reduced at a high temperature to the state of protoxide in a borax-bead, with excess of boric acid, and is so readily peroxidised at a dull-red heat, when crystallised along with borate of zirconia, that there seemed good reason to refer the change in the spectra to temperature rather than to the state of oxidisation, until after it was found that they were due to uranium. By gently flaming the crystalline bead, the spectrum is entirely altered, and presents five well-marked absorption-bands, all of which occur at the red end, where no trace of bands exists in the case of ordinary uranic salts. I have not found any other element besides zirconia which causes uranium to give similar abnormal spectra, at all events in similar conditions. A few have special characters, but the majority exert little or no influence. Even when the blowpipe-beads are crystalline, they show only the usual spectra of the oxides of uranium. Moreover no such great change in the character of the spectra of other elements which give absorption-bands is to be seen when they are combined with zirconia. So far as my present experience goes, it seems as if such very abnormal spectra were met with only in the case of these remarkable compounds of zirconia with the oxides of uranium. These facts now put us in a position to explain why certain zircons give three different spectra. Some jargons (usually those of a green tint) contain a little uranium so combined that the characteristic spectrum is only faintly visible, whereas, after ignition, the intensity of the absorption bands is permanently increased often to a very great extent, and this more powerful action on light is accompanied by an increase in hardness and in specific gravity, sometimes as much as from 4·20 to 4·60. These changes are approximately proportional to the amount of uranic oxide in the various specimens, as shown by comparing the spectra of the blowpipe-beads. On the whole, since this abnormal type of spectrum is so characteristic of combination with zirconia, it appears probable that the effect of a high temperature is to cause the uranic oxide to combine more specially with the zirconia, as though the greater part existed naturally as a silicate, but after ignition as a zirconiate. We may also apply the same explanation in the case of zircons, more or less strongly coloured by other oxides, which become almost colourless when heated; and this unexplained peculiarity of zircons may depend on the fact of zirconia being able to play the part of both a base and an acid, which as compared with silica has an affinity for bases varying according to the temperature. The brown-red zircon from Ceylon, named at page 514 of my former paper, gives a spectrum precisely like that of the borax blowpipe-beads crystallised after treatment in the deoxidising flame. No doubt it contains uranous oxide. These facts thus clearly show that the various spectra which seemed to indicate the presence of a new element existing in three different physical conditions, are in reality only characteristic of the two oxides of uranium combined with zirconia, or not in combination. Perhaps some may think that my having been thus led astray shows that little or no reliance can be placed on the method of investigation employed, but I contend that the mistake was due to its being such an unexpectedly delicate test for uranium; moreover, the error was ultimately corrected by a further development of the same method. As far as the interests of science are concerned, there is no need to regret the general result. We have lost what appeared to be good evidence of a new earth, but have gained an almost entirely new system of blowpipe testing, which enables us to detect such a minute quantity of some substances as could not be recognised by the ordinary means.

H. C. SORBY

* Figs. 1 and 2 of my former paper.

† For both of these I am indebted to my kind friend Mr. David Forbes.

THE RELATION OF THE STATE TO SCIENCE

WE have referred in another column to Lieut.-Colonel Strange's valuable paper, read before the Society of Arts. The following is a report of the more important part of it. After giving a sketch of the history of the movement in favour of a recognition by the Government, of the necessity of defining the relations which should subsist between the State and scientific education throughout the country, commencing with the meeting of the British Association at Norwich in 1868, Colonel Strange proceeds to state the points which he thinks should be especially kept in view in the proposed inquiry. These are:—

1. The scope which the inquiry should include.
2. Some of the probable results of the inquiry.
3. The constitution of the Commission itself.

1. *The Scope of the Inquiry.*—The first thing to do will certainly be to take stock of what is now done by the State for advancing science. A reference to the parliamentary votes shows a considerable expenditure on science, in some form or other. The British Museum receives upwards of 100,000*l.* a year, the South Kensington Museum 92,000*l.*, and the Science and Art Schools 74,000*l.*, but in these cases a large proportion goes to art, not wholly to science.* The Royal Observatories of Greenwich, Edinburgh, and the Cape of Good Hope, the Royal School of Mines, the Ordnance Survey, the Hydrographic Department of the Admiralty, are all scientific branches of the admi-

* The total amount voted in the Estimates, for 1869-70, to maintain the "Science and Art Department of the United Kingdom" was 225,253*l.*

nistration, supported by the State at considerable cost. Enormous sums of money have been spent on special inquiries of a scientific character, such as those on armour-plate structures, ordnance, ammunition, small arms, explosive agents, and projectiles. The Parliamentary votes show also 10,000*l.* a year as given for meteorological observations. We also find a large number of small sums, forming, however, a considerable aggregate amount, given in aid of the funds of various colleges, universities, and museums; in some instances towards the salaries of specified professors, in others towards general purposes. The Royal Gardens of Kew receives 22,075*l.*; the Botanical Gardens of Dublin and Edinburgh receive respectively 1,931*l.* and 1,893*l.*; 20,900*l.* is spent on geological, and 92,790*l.* on the Hydrographic Department and naval surveys, besides very large sums on other miscellaneous objects.* Some of the institutions above named issue reports, from which the results of the expenditure on them may be inferred. In other cases this is not done. The wording of the votes seldom conveys any useful information on the subject whatever, and sometimes conveys incorrect information. The grant of 1,000*l.* a year distributed by the Royal Society is an example of such inaccuracy. This is said, in the words of the vote, to be given to the Royal Society "to enable the society to carry on certain experiments for public objects," whereas, instead of being given, as here stated, to the Royal Society, or for public objects, it is given to the community at large, and a committee of the Royal Society undertakes gratuitously the very laborious task—which does not even receive nominal acknowledgment—of distributing it with the strictest economy and impartiality, to such persons, whether belonging to the Royal Society or not, as may prove their ability to make good use of the aid they solicit in prosecuting scientific research.

Now, the results supposed to be obtained by the large expenditure recorded in the estimates may be thus enumerated:—(1). The maintenance of the efficiency of the public services in matters of a scientific nature. (2.) The teaching of science, directly, as by payment of professors, or indirectly, as by the maintenance of museums, botanical gardens, and the like. And (3), direct or indirect scientific progress, whether observational or experimental. What is wanted is, a clear statement of the degree in which these several results are attained in each particular case. With this information before us, we shall be in a position to arrive at trustworthy conclusions as to whether the money brings in each case an adequate return; whether the inadequacy of the return is due to defective organisation or to abuse; and whether, therefore, a more satisfactory result may not be obtainable in each case by a process of remodelling, without increased expenditure. We shall also ascertain, probably, that the whole expenditure in some particular case is needless, and is at present absolutely wasted. We shall learn, too, no doubt, that there is much divided, and probably much utterly undefined, responsibility in many of the cases in which large sums of public money are spent. Another fact, already patent, will be brought out prominently, namely, the entire absence of any pervading system by which the expenditure on scientific objects is regulated. Finally, it will clearly appear that the expenditure is very partially distributed, some branches of science receiving a very large amount of assistance from the public purse, whilst others, of equal importance to the community, receive none at all. This taking stock of our present scientific arrangements, it can hardly be doubted, is an absolute necessity to the success of the proposed inquiry.

Much of the information above adverted to will bear more or less on the question of "the higher scientific education." But in indicating the scope of the inquiry in this direction, it is very desirable that a clear conception should be formed of the meaning of this phrase. My own conception of it is this. Public opinion has decided that science should form part of the general education given at large and public schools, and at the universities. Such scientific education should comprise the elements of scientific knowledge, and the results of scientific labour, so far as these results are generally accepted as settled. Teaching of this kind forms, in my opinion, a portion of the great educational question which has been for some time occupying public attention, and which is now in a fair way of being put on a satisfactory footing. To impose on the Royal Commission the consideration of such teaching would be doing the same work twice over, and adding, therefore, unnecessarily to their already most laborious inquiry. But beyond the scientific teaching of schools and universities, there is much to be done in order to train advanced students to become investigators and observers, and this I conceive to be the object intended to be described by the phrase "higher scientific education."

It is maintained by very high authorities that it is beneficial intellectually to the investigator himself to have to teach, on account of the mental discipline and the habit of precise thought which it imposes on him. At present, unquestionably many of our best investigators are teachers also, and in all Continental scientific systems the two functions are combined. Two conditions seem important. First, that an investigator should not be required to impart the mere rudiments of scientific knowledge, but that his students should be far advanced before they come under his tuition; they should, in fact, be men who had already gained some distinction at the universities or elsewhere, and who had resolved on following science as a profession. The second condition is that the labour of teaching should engross only a moderate portion of the time of the investigator, leaving him ample leisure and spare energy for original research. At present, this latter condition is precisely reversed in the cases of most of our professors engaged in investigation, and we accordingly only reap the benefits of a mere residuum of their highest faculties.

Another matter connected with scientific teaching is considered by persons engaged in that important occupation to require attention, namely, the possible effect on independent educational institutions of rival State schools of science. The apprehended interference with such interests may perhaps be obviated by restricting State aid to the "higher" teaching which I have attempted to define, leaving the preparation of students for such higher teaching to the universities and other institutions of an independent character. But before any rules on this subject can be laid down, it is obviously necessary that the exact amount and kind of action now taken by the State in respect of teaching, and the effect of that teaching, both on scientific progress and on independent interests, should be ascertained with the utmost care.

It is also desirable that the Commission should collect the fullest possible information regarding all foreign scientific systems, down to the latest period. I by no means consider that any of these systems in particular is so perfect as to justify our creating a servile imitation of it. But it is only the part of wisdom, before organising our own scientific administration, to examine carefully the results attained abroad by nations whose experience in such matters is now very extensive. This examination will suggest many arrangements that we may safely adopt, and, no doubt, some that we should do well to reject. Not even the nucleus of a scientific system at present exists in England, and we are therefore the more free to shape, on the best available models, the organisation which a full inquiry will undoubtedly show to be necessary.

A great mass of facts connected with both scientific teaching and scientific investigations having been thus accumulated, the next step will be to digest and analyse them. The result of this most important process will be to show—first, what is redundant; secondly, what is imperfect; and thirdly, what is altogether wanting. It will indicate cases in which separation is desirable, as, for instance, cases where the concurrent cultivation of two or more branches of science, not naturally allied, tends to impede the growth of each. Cases will also occur in which combination would be beneficial. But one of the most important results of the analysis will be the bringing to light the scattered character of our scientific efforts; almost every department of the State having charge of some scientific institution—the Admiralty of one, the War Office of another, the Board of Trade of a third, and so on, a dispersion which is absolutely prohibitive of harmonious system, of progressive improvement, of efficient superintendence, of economy in expenditure, and of definite responsibility.

The final process will be to reduce to order the chaos of which I have merely attempted a broad indication. This will probably consist in a total re-arrangement of the internal organisation and the official distribution of our scientific institutions, with a view to concentrated superintendence and responsibility. It will also involve a revision of scientific staffs and salaries, with all the attendant questions of patronage, promotions, distinctions, privileges, and pensions.

2. *Some of the Probable Results of the Inquiry.*—The first of these will be the accumulation of a vast amount of facts and opinions, collected from every available source, and from the most competent authorities, regarding an extensive variety of

* The amounts above given are quoted from the Civil Service Estimates for 1869-70, those for the present year not having yet been published.

subjects of which we are at present in a state of comparative ignorance. If the inquiry produced no other immediate fruits than these, it would have performed a priceless service. Another result will be that we shall see for the first time what are the principles which should determine the action of the State for the advancement of science. At present there exists the most violent conflict of opinion on this subject, from those who hold that State intervention in science is unjustifiable and disadvantageous, to those who desire such intervention to be universal. Between these extremes there lies the middle and more reasonable section of thinkers, who recognise in the State simply a machinery for doing, on the part of the community, whatever is generally advantageous to the great mass of the people, but which transcends the power of individuals to perform. To discriminate fairly between the branches of scientific exertion which should devolve on the State and those which should be left to private energy, is one of the most valuable results that can be expected from the inquiry.

We may hope, as another most important result, that a central ministerial administration of scientific affairs will be shown to be necessary. In all other civilised countries a Minister of State is charged with this duty. It seems absolutely impossible to organise or maintain in an efficient state anything like a harmonious scientific system, without a dominant authority presiding over the whole. There are already indications of a coming Minister of Public Instruction, to administer the proposed national system of primary education; it can hardly be doubted that he should also have charge of whatever relates to State intervention in science.

The creation of such new scientific institutions as may be proved to be necessary, is another result that may be looked for. Though I have long been of opinion that the want exists, I do not think that the time has yet arrived to indicate how it should be supplied. The inquiry will develope clearer and more consistent estimates of the extent of the want, and of the best mode of meeting it, than, in the absence of full information regarding existing institutions, anyone can now hope to form. The cost of new scientific institutions alarms many persons who have only superficially examined such questions, but it will be probably found that increased expenditure in some directions may be met by retrenchment in others, and that no great change in the aggregate outlay on science will have to be made. On the other hand, we may feel sure that no outlay whatever will be recommended by a Royal Commission, unless it be incontrovertibly proved that such outlay will be beneficial to the nation.

Eventually, the responsibility of sanctioning increased expenditure for scientific purposes must rest with Parliament, by whom any proposals of that kind will be most scrupulously examined.

3. *The Constitution of the Commission.*—This is of vital importance. If its constitution be not such as to command, not only the confidence of the public generally, but also that of men of science, it cannot hope for success. The necessary elements in such a body seem to be administrative capacity, impartiality, and varied scientific knowledge. The first two elements will be secured by the nomination of persons versed in public affairs, and of high and independent station; the last by the due representation of the main branches of scientific activity. Probably four scientific members will suffice, to represent respectively, (1) Mathematics, including Astronomy; (2) Chemistry; (3) Physics; and (4) Natural History. To give a decided preponderance to either one of these great subdivisions will create strong and well-founded dissatisfaction. However lamentable the fact, it is certain that men engaged in one branch of science are very apt to underrate the importance of all others. The decision of a physiologist on an astronomical inquiry, or that of a mathematician on a matter connected with biology will be received with jealousy, a jealousy not by any means in most cases destitute of reasonable foundation. The subjects which will come before the Commission will be so difficult and so various, that four of the ablest men of science in their different departments will not be found more than will be necessary to give weight to the conclusions at which the Commission may arrive, and they should be men admittedly representative of their respective departments.

In the remarks which I have ventured to make, I have not dwelt on the importance to a civilised nation of progress in scientific knowledge. I have felt that I might safely take this for granted in addressing the Society of Arts, a society whose efforts have been during so long a period devoted to the promotion of such progress, and who do not require to be told that our commerce, our arts, our national supremacy on land and at sea, and our everyday conveniences are, more or less, dependent on our application of the laws of nature and the properties of matter. Whether or not an exhaustive inquiry into the state of science in England is imperatively needed, and what should be the scope of that inquiry, are the questions which, I believe, we have to-day met to discuss. It appears to me that the time for such an inquiry is opportune.

At no period of our history has there been so great a readiness to place administrative power in the hands of the Government. Public opinion acts now so energetically and effectually in the legislature, that the old jealousy of Government interference has been almost entirely dispelled. The tendency of the day is rather to impose fresh duties on the Government than to restrict its action. Men's minds, at the present time, view without apprehension, and examine with more impartiality and a higher discrimination than at any former period, proposals for radical changes. The nation has, moreover, been roused from the apathy with which it used to regard the ignorance of the masses, and is prepared for measures to redress the evil which, even ten years ago, would not have been listened to. It cannot be doubted that an equal readiness will be shown to examine with calmness and candour well-considered proposals to place on a proper footing a department of the State's duties which has never as yet undergone a strict and methodical examination. The nation requires primary education, and will enforce it upon those whom it is to benefit; it insists on the teaching of science in schools and universities; will it not approve of measures without which that teaching must be comparatively fruitless—measures calculated to attain the ends to which teaching is but a means—a more perfect knowledge of nature, and more absolute sway over her forces and her laws?

SCIENTIFIC SERIALS

THE *Student and Intellectual Observer*, New Series, No. 2, for April, contains an article entitled "Animals as Fellow-Boarders," being a translation of Von Beneden's valuable paper on *Commensalisme*, read before the Belgian Academy, describing the habits of creatures who may be said to board together, but whose association is distinct from that of victim and parasite. They are of two kinds, Free Fellow-Boarders, such as the tiny pea-crab, which lives in mussel-shells; and the Fixed Fellow-Boarders, like the barnacles which cover the skin of whales.

THE *Journal of Botany, British and Foreign*, New Series, No. 2 (double number for March and April) contains the following original articles: On two new British *Hepaticæ*, by Dr. Carrington; a fifth decade of new Chinese plants, by Dr. Hance; on *Rosa sepium*, by Mr. J. G. Baker; Addenda to the "Cybele Hibernica," by Mr. Ralph Tate; notes on Ray's "Hortus Siccus," by Dr. H. Trimen, with other shorter papers; also reports of recent additions to our moss and lichen flora, by Dr. Braithwaite and Rev. J. M. Crombie; a continuation of Mr. Baker's Review of the genus *Narcissus* from the *Gardener's Chronicle*, with other extracts and translations, reviews of new publications, proceedings of societies, &c., &c.

THE *Revue des Cours Scientifiques* for March 26 contains report of a Lecture by M. Paul Bert, on Sympathetic Nervous Actions, an article by Alph. Favre on the Existence of Man in the Tertiary Epoch, and a notice of Prof. Harkness's Spectroscopic Observations. The number for April 2nd is almost entirely filled by a translation of Prof. Tait's lecture before the University of Edinburgh, on the characters of a true science; and report of a lecture by M. Lorain at the Hospital Saint Antoine at Paris, on Scientific Medicine.

IN the *Deutsches Archiv für Klinisches Medicin* (xiii. and xvii. Heft. 1, received March 12), Liebermeister, of Basle, describes a very ingenious apparatus, constructed under his superintendence, for determining quantitative variations in the production of carbonic acid by man, and gives several examples of the results obtained. Amongst other conclusions he shows that the increase of carbonic acid in reading and singing is only to a small extent attributable to increased exertion consequent on fuller ventilation of the lungs, but is essentially due to the increased muscular energy exerted in the performance of those acts.

REICHERT and Dubois Reymond's *Archiv für Anatomie und Physiologie*, Heft. vi., 1869, is almost entirely occupied with a