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HISTORY IN THE ARCHIVES OF THE ROYAL SOCIETY[1]

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THE archives of the Royal Society are rich in materials that illustrate various aspects of the history of the last three centuries. They have, of course, a special character, since they refer almost entirely to the matters in which the society has concerned itself, grouped under the general title of "The Improvement of Natural Knowledge." But these matters have increased in importance with the passing years and are now a subject of the first concern of the whole world. The effect of science upon social relations and social conditions has become very great, and the gains are obvious. Yet science does not appear to be in all cases beneficent. It has become a matter of anxious consideration whether or no the increase in the knowledge of nature must necessarily bring evil as well as good. Is there a fault to be remedied, and if so where does the fault lie? These questions have roused a debate which is even now in progress, and some hard thinking is being given to them.

It is of some help, I think, to consider the steps by which the present position has been reached, and the Royal Society archives may be used to provide the necessary illustrations. For that reason I hope that you will find it of some interest if, with that object in view, I refer to some of the papers and letters which they contain.

A few "virtuosi," to use the contemporary phrase, who met for discussion and experiment in the middle years of the seventeenth century were weary of the miseries of the civil war, and were glad to turn their thoughts to the consideration of natural phenomena over which the passions of men had no influence. Experimental science had long tempted thoughtful minds, and now the first founders of the Royal Society threw

[1] Pilgrim Trust Lecture, delivered before the National Academy of Sciences, April 24, 1939.

themselves with thankful relief into a work which seemed to them to be both a pressing duty and an absorbing occupation. They were like boys let out of school rushing out into the surrounding world to explore brooks and hedges and anything that seemed interesting. When I take down the first volumes of the *Transactions* from their shelves or look through the early manuscripts at the Royal Society, I feel as if I was turning out schoolboys' pockets and finding the usual assortment of mixed oddities.

In its first efforts the society was mainly concerned with the collection of information. The leading fellows sent questionnaires to various parts of the world which in their demand for comprehensive detail would have done credit to any inquisitive department of a modern government. An admirable example is to be found in the series of questions drawn up by Lord Brouncker and Mr. Boyle and approved at one of the earliest meetings of the society; in which most appropriate suggestions were made as to what should be looked for on an ascent of Teneriffe. It shows no little knowledge and penetration to inquire whether a "filtre or siphon" would work as well at the top of the mountain as at sea level, whether a bell or watch or gun would give the same sound, a flame have the same appearance, whether a pendulum clock went at the same rate, whether birds of heavy flight would fly as well or better or worse, and so forth. It was quite apt to ask what alterations would be found in living creatures carried to the top, both before and after feeding, and "what the experimenters do find in themselves as to difficulty of breathing, faintness of spirits, inclination to vomit, giddiness, etc." On March 28, 1672, Lord Henry Howard presented the answers to a series of questions on Barbary, where a retainer of his had recently been traveling: a remarkably pictorial account of the country and its inhabitants. It was expected apparently that some trace of the arts and sciences were to be found there, no doubt because it was known that the Arabian races had handed on the knowledge of the old world to the new. But there was no learning at all. In particular "there were no chemists except Jews and Christian slaves that distilled brandy in jars." So too a good account is given of Hudson's Bay and its people by a Captain Guilliaume and a Mr. Bailes, who had recently voyaged there. Naturally most of the information related to navigation and trade, but it is interesting to find also an account of the Maneto or Supreme Power and of his priest the Pawaw. The early records contain many such questionnaires and replies thereto.

Robert Boyle was the center of a vast correspondence on scientific and other matters, and fortunately a large collection of his papers is possessed by the society. Many of these have been published in his well-known "Life and Works." Quite a number of them crossed the Atlantic, and you will not blame me if I choose some of them to illustrate what I have to say. They were in the main of the informative type on which such great value was set. Thus a certain P.S. writes from Virginia on August 29, 1688, describing humming birds, also wampum, roanoke and pook, which were forms of currency. The trade measurement of length was the primitive cubit. The climate of New England was a frequent topic; it was supposed to be changing for the better. Perhaps under improving conditions the settlers were less susceptible to its rigors.

The governor of Boston, Leverett, and the deputy governor, Symonds, with other of their fellow citizens write to Boyle in protest against charges of disloyalty to the King, anxiously rebutting accusations of neglecting the baptism of infants and so forth. In 1682, Hezekiah Usher begs the remittance for 21 years of the King's claim for one fifth of all minerals recovered, so that prospecting may be encouraged.

Boyle's correspondence was, as the last two extracts show, by no means confined to scientific matters. After all, the first founders of the society were either statesmen themselves or closely connected with statesmen and might well be supposed to be proper persons to be entrusted with important news. Thus Richard Wharton writes from Boston in 1676, warning Boyle that the French are working round the interior of the settlements towards Carolina and the South. In 1684 Randolph writes from New England of the possibility of drawing on the vast forests of Maine for supplies of masts and timbers for the Navy, and discusses methods of making pitch and resin which are a secret of the French. John Winthrop writes in the same strain, urging the Royal Society to approach the government on the matter: he explains that there are sawmills handy to rivers, houses and provisions for workmen who may be sent, that small ships up to 400 tons have already been built. The supply of timber for the Navy was one of the greatest anxieties of Great Britain, from the time of his correspondence until steel replaced wood. Dry rot was a terrible curse from which the navy suffered more than the merchantmen, because the latter were more often aired and open to inspection during the loading and unloading. A strange story of its ravages is told by Ramsbottom in the *Essex Naturalist,* Volume XXV. Among the incidents of that story is the probable failure of the *Speedwell* to accompany the *Mayflower* on acount of dry rot.

It is well known that Boyle was deeply interested in the conversion of the Indians and that the Society for the Propagation of the Gospel owes much to his initiative. In 1664 he receives a letter from John Endicott, of Boston, describing the progress of the mission. John Eliot, also of Boston, writes frequently, expressing deep gratitude, and hopes for further help.

His address to Boyle was always eloquent, as for example "To the Right Honorable Learned abundantly charitable and constantly noursing Father."

In modern times it is an honor and an honor only to be elected a correspondent of a learned society. But a correspondent of the Royal Society in its early days was expected to correspond. When Cotton Mather was advised that he had been elected a fellow he wrote in 1715 to his friend Richard Waller, the society's secretary—the letter is in the society's archives —saying that

> . . . the tendency [of the society] to Refine and Sweeten the minds of men, and reconcile them unto Just Regards for True Merits in one another, with an extirpation of that noxious clamour the party spirit, and finally how generously the more polite Literators of the world go on in it, with a decent contempt on the Banters of the Bruitish among the people, but the result of his consideration will be that it will be a greater honour to be taken into the list of your servants, than to be mixed with the great men of Achaia.
>
> One who is entirely of that opinion, having been so listed with you has been desirous to discharge his obligations by agreeable assiduities, and therefore besides what every year brings you from him as an addition of Curiosities to the rich and vast assessment you are preparing he has bestowed a few hours upon the Philosophical Religion which he now humbly tenders to your acceptance.

The "Curiosities" here referred to became a famous object of interest in London; the collection was known as the "Repository." It grew to so great a size that the society found it unmanageable, and handed it in 1782 to the British Museum, which had been founded a few years before in order, in the first place, to contain the collections bequeathed to the nation by Sir Hans Sloane. Sir Hans was president of the society from 1727 to 1741.

The "Banters of the Bruitish" must clearly refer to the scornful comments of many clever men who did not sympathize with the experimental study of the world, who resented the intrusion of the new knowledge and laughed at the apparent futility and irrelevance of its beginnings. If they did not foresee the magnitude of its consequences they were little more at fault than the experimenters themselves. How could intelligent men waste time on objects so small that they must be examined under the microscope? Or on the consideration of such intangible substances as the air? How could they give serious attention to the abnormalities and monstrosities that idle correspondents thrust upon them? And, of course, the society did at first give their time to many accounts that even then must have looked ridiculous to men of a serious and settled mind. There were, for example, reports of a calf that had its hair inside out, of a man who squinted only on alternate days, of another who could not see if his hair were suffered to grow more than an inch long. It must have been quaint hearing when Dr. Tyson, at a meeting of the society, declared that one of his teeth having been drawn at Oxford some years before had been replaced and had apparently taken root again, since it was still of use. In those early days of inquiry it was of course necessary to sift all information that came to hand, but it would certainly be difficult for the unscientific mind to see the point in all cases. Dean Swift was a violent critic of the society's doings. It will be remembered that in his stay in the island of Brobdingnag Gulliver had an encounter with two wasps nearly as big as himself. He slew them with his sword and cut out their stings, which he brought eventually to England and presented to the Royal Society for its "Repository." In the voyage to Laputa, Gulliver found men, corresponding obviously to the physiological members of the society, who did remarkable experiments on men and animals. It is curious that Swift's wild inventions, which were intended as caricatures, are not unlike some of the beneficent methods of modern healing. It would not be very difficult to carve out a claim for Swift to be in some respects a pioneer of medicine as it is practised to-day.

These oddities were, however, an insignificant part of the society's proceedings. Of far more importance among the society's early papers are such as deal with the pressing questions of the day. Navigation claimed much attention. I have already referred to the anxieties respecting a sufficient supply of masts for the Navy. Perhaps the Dutch and French were aware of those difficulties when, as Ramsbottom remarks, they were accustomed to fire high in a sea fight.

At the end of the seventeenth century ships were growing considerably in size, since now they must become accustomed to the crossing of the Atlantic. Many English ports were unable to provide water of sufficient depth at all states of the tide, and tide tables were urgently required. Their calculation required the cooperation of mathematicians and astronomers. The archives contain of course many communications relating to the foundation of the Royal Observatory at Greenwich.

Pepys, when he was president of the society, begged continually for information on any matter whatever that might assist him in his care for the Navy. Probably he was really disappointed when Sir William Petty's double-bottomed ship turned out so badly, though he had made his bet that it would. Petty, a very able man, had supposed that a ship resembling in form two ships lashed side by side would stand up to a cross wind better than a ship of ordinary design. The idea was that, of course, which is embodied in the outrigger of some Polynesian races. Again, there is an interesting note in the account of the *Proceedings* of July 28, 1686.

. . . it was remarked that sheathing with lead was the best expedient (for preserving ships from the worms) and found to be so by the experience of Sir Anthony Deane; but that the carpenters finding it against their profit opposed it by affirming that the iron of the pintles of the rudders of ships so sheathed were much more apt to be corroded by the sea water than those sheathed with wood which yet was a groundless supposition.

The carpenters had more reason than was supposed: we know now that electrolysis can be exceedingly troublesome.

So also the ventilation of coal mines was an urgent question, and is frequently referred to in the archives. It had become necessary to dig deeper than before. The accumulation of water became a serious hindrance and the many noxious damps were often fatal. Air pumps and water pumps are dealt with in numerous well-known papers by Boyle, Hooke, Papin and others. Sir Robert Moray wrote on the ventilation of mines in Belgium. There was much correspondence on the subject. Its general character may be illustrated by an extract from a letter which a certain Dr. Jessop of Yorkshire wrote to the society in 1675. Let me give it in its original form, which now sounds so quaint.

There are four sorts (of damp) common in these parts. The first is *Ordinary Sort* of which I need not say much being known everywhere: the external signs of its approach are the candles burning orbicular and the flames lessening by degrees until it quite extinguish; the internal, shortness of breath. I never heard of any great inconvenience which anyone suffered by it, who escaped swooning. Those that swoon away and escape an absolute suffocation are at their first recovery tormented with violent Convulsions, the pain whereof when they begin to recover their senses, causeth them to roar exceedingly. The ordinary remedy is to dig a hole in the earth and lay them on their bellies with their mouths in it: if that fail they tun[2] them full of good Ale: but if that fail they conclude them desperate.

These few extracts from the records of the society will serve, I hope, to convey an impression of the character of the society's activity in its early days, when first an organized attempt to collect knowledge by experiment and observation began to exercise its influence. At whatever point one picks up the story as it is told in these old records, one finds it full of interest, which lies not only in the subjects that are dealt with, but also in their relation to the activities of the time, and to the men themselves whose handwriting lies before one.

It is to be observed that these records are easily read by an educated man. Those who wrote them had in general no thoughts which the educated man could not follow, nor was it necessary to use terms which were not in ordinary use. Newton's "Principia" would, of course, be intelligible to a small number only, but in general the "virtuosi" spoke a common language. The days of specialization and division into separate societies had not begun. How great is the contrast with the publications of a modern learned society!

It is also to be observed that there is no strict reckoning of services rendered, and no calculated recompense. Men like Hooke and other immediate servants of the society were paid for their work as was necessary and right, though the amount was incommensurate with their deserts. But the labors of the enthusiastic fellows and of their correspondents in all parts of the world were given freely. Indeed the society had no money to pay with. It received no financial assistance from the government, and the fellows' subscriptions (which, by the way, the treasurer found it remarkably difficult to collect) covered only the necessary expenses of the meetings. When the society decided to print the "Principia" Dr. Halley himself provided the necessary funds. To this day, the fellows give without reward the services which their connection with the society entails. But I do not ask for any special commendation; the point is that such free service is common among learned societies, and is certainly a chief reason why they are held in respect.

The general intelligibility of the communications to the Royal Society persists for a long time. The calculations of the astronomers, the mathematicians, opticians and so forth appealed naturally to a limited number, but still we may suppose that fellows were able to understand the most part of that to which they listened. Perhaps it may be said, broadly, that the change begins when new terms must be invented to describe the increasing complexity of observations, and new units for quantitative description. Electricity and magnetism have been chiefly responsible; so that the experiments on frictional electricity which were so popular in the middle of the eighteenth century are especial objects of interest. The progress of the subject is illustrated in the society's archives by the many papers and letters of Watson, Franklin and others. Franklin's communications came by way of his friend Collinson, who gave them to Watson for presentation to the society. Watson was himself a keen student of frictional electricity; and it would seem that some of the important experiments were made by Franklin and himself independently. But Franklin was of course the greater man, and Watson gave him full praise: "Although there are in the work some few opinions in which I can not perfectly agree with him I think scarce anybody is better acquainted with the subject of electricity than himself." Franklin was advised by his friend Mitchell that the paper on the subject of the identity of the lightning flash with the sparks of the electrical machine were received with

[2] A tun is a cask that bulges in the middle and the meaning of the verb is associated with that of the noun.

laughter by the Royal Society. But the records in the *Journal Book* and elsewhere seem incongruous with such an occurrence. The warmth of Watson's praise, though he was an independent worker, his recommendation that Franklin's papers should be accepted, the repetition of Watson's commendation by the president when awarding Franklin the Copley medal all go to show that there was probably no more than a hesitation to accept Franklin's view of the particular paper to which Mitchell referred; and the absence of some papers from the *Transactions* may well have been due to an arrangement with Collinson, who regarded the communications which he had received as private letters. At that time the *Transactions* of the Royal Society were not printed by the society itself but privately and independently.

The many papers in the archives that refer to frictional electricity form in themselves an interesting collection, showing the keen interest felt in the phenomena by experimenters in Europe and America; and they give additional strength, if it were needed, to Franklin's great reputation.

There is an interesting letter of Franklin's which describes an experiment of his friend Kinnersley's, who was unable to give a satisfactory explanation of it. Franklin was himself perplexed at first. The experiment consisted in the "electrification of the air in a room" or even the air outside; when the air was changed the electrification did not disappear. At first Franklin thought that there might be some stationary medium which held the electrification, and allowed the air to percolate through it: but he observed that Kinnersley had put his two light bodies, by the repulsion of which the charge was observed, in a glass phial, and he came to the conclusion that the air gave some of its electrification to the glass.

Thus electricity was already, in the middle of the eighteenth century, offering a new field of experimental inquiry, and the importance of it was becoming realized. In the words of Martin Folkes, president from 1741 to 1752:

> Electricity seems to promise an inexhaustible Fund for Inquiry: and sure *Phenomena* so various and so wonderful can arise only from Causes very general and extensive, and such as must have been designed by the Almighty AUTHOR OF NATURE for the Production of very great Effects, and such as are of great Moment to the System of the Universe.

The numerous papers on frictional electricity form one of the most interesting sections of the archives during the eighteenth century. The society's membership did not equal in brilliance that of the centuries that preceded or followed. But there were several great subjects of consideration besides that in which Franklin made so prominent a figure. A large collection of Fahrenheit papers shows the interest taken in thermometers in the earlier part of the century. Another large collection deals with inoculation against smallpox. At the end of the century Rumford describes his beautiful and valuable experiments on heat: he is prolix of words, but he makes excellent reading. He was, of course, a pioneer in the experimental study of the nature of heat. His work is well illustrated in the society records. At the turn of the century, 18th to 19th, the chemical investigations of Humphry Davy introduced a brilliant period in British science, and these also are well recorded. The first quarter of the nineteenth century was not, however, a happy time for the society. Internal dissensions and unchecked growth of membership and the formation of societies which were formed to take over special sections of the society's work till then unrestricted, all tended to reduce the value of the records and their interest. There were denunciations of the management and laments over the decline of science. Yet one of the greatest periods of scientific discovery had already begun, with Young, Fresnel, Davy and Faraday. But now the language began to be more difficult to the uninitiated. When the phenomena of electricity, magnetism, chemistry, light came to be studied in their mutual relations, the new world in which they figured was difficult of entry. This was not only because ideas were new and could only be represented with the aid of analogues, such as current, pole, capacity and the like, but also because new terms had to be invented to provide labels for conceptions which had never entered men's minds before. What, for example, could such words as anode and cathode mean to the non-electrician? So the ordinary reader is left behind, and the language of science becomes rapidly specialized.

It is interesting to observe the care with which Faraday chose his terms. He was in the habit of consulting Whewell, the master of Trinity College, Cambridge; the correspondence is preserved in Trinity College Library and in the Royal Institution. A letter in the possession of the Royal Institution reads as follows (Whewell is replying to Faraday):

> . . . I still think *anode* and *cathode* the best terms beyond comparison for the two electrodes. The terms which you mention in your last show that you are come to the conviction that the essential thing is to express a *difference* and nothing more. This conviction is nearly correct, but I think one may say that it is very desirable in this case to express an *opposition* a contrariety, as well as a difference. The terms you suggest are objectionable in not doing this. They are also objectionable it appears to me in putting forward too ostentatiously the arbitrary nature of the difference. To talk of Alphode and Betode would give some persons the idea that you thought it absurd to pursue the philosophy of the difference of the two results, and at any rate would be thought affected

by some. Voltode and Galvanode labour no less under the disadvantage of being not only entirely, but ostentatiously arbitrary, with two additional disadvantages; first that it will be very difficult for anybody to recollect which is which; and next that I think you are not quite secure that further investigations may not point out some historical incongruity in this reference to Volts and Galvani''

. . . I am afraid of urging the claims of *anion* and *cation* though I should certainly take them if it were my business—that which goes to the *anode* and that which goes to the cathode appearing to me to be exactly what you want to say. To talk of the two as *ions* would sound a little harsh at first: it would soon be got over.

The selection of the terms anode and cathode were based on a suggestion made by Faraday. In order to obtain a description which he could remember he supposed his electrolytic trough to be placed parallel to the equator, and the current in the trough to run in the direction in which a current would have to run round the earth in order to give to the earth its observed magnetism. This implied that the current ran from east to west. It came, therefore, from the sunrise and went to the sunset, and the terms anode and cathode were taken as describing the way of the sun in the morning and in the evening.

You may be interested if I recall to you an item of history. Not long ago the council of the Royal Society decided to open some sealed letters which had been deposited with the secretaries a century ago and more. There was no apparent reason why their contents should still be kept secret. One of them was written by Faraday in 1832. It read as follows:

Certain of the results of the investigations which are embodied in the two papers entitled Experimental researches in Electricity, lately read to the Royal Society, and the views arising therefrom, in connexion with other views and experiments, lead me to believe that magnetic action is progressive and requires time; *i.e.*, that when a magnet acts upon a distant magnet or piece of iron, the influencing cause (which I may for the moment call magnetism) proceeds gradually from the magnetic bodies, and requires time for its transmission, which will probably be found to be very sensible.

I think also, that I see reason for supposing that electric induction (of tension) is also performed in a similar progressive way.

I am inclined to compare the diffusion of magnetic forces from a magnetic pole, to the vibrations upon the surface of disturbed water, or those of air in the phenomena of sound, *i.e.*, I am inclined to think the vibratory theory will apply to these phenomena, as it does to sound, and most probably to light.

By analogy I think it may possibly apply to the phenomena of induction of electricity of tension also.

Faraday had learnt the advisability of preserving evidence such as this in case he might seem to have adopted the ideas of others. It shows that Faraday's conception of electromagnetic pulses or waves occurred to him long before he published his paper on "Thoughts on Ray Vibrations" in 1846. Curiously enough, when the society's librarian was helping me to gather these few notes, a slip of paper fell out of one of the books consulted. It is in Maxwell's handwriting:

The electromagnetic Theory of L^{t} as prop^{d} by him (Faraday) in Thoughts on Ray Vibrations (Phil. Mag. 1846, May or Ex.Res.III.p.447) is the same in substance as that wh. I have begun to develope in this paper (A Dyn^{l} Th^{y} of the E^{c} Field. Part VI pp497–5 Ph Tr 1865) except that in 1846 there were no data to calculate the vel of propagation. J.C.M.

The passage was subsequently incorporated in Maxwell's papers.

Many groups of papers in the archives relate to work done for the government, or for national enterprise, eclipse expeditions, biological and geodetic expeditions and so on. There is an interesting bundle of Sabine papers which have not yet been published. Sabine (1788–1883) was largely responsible for magnetic surveys in various parts of the world. Not a little of it is concerned with New England. There are letters from G. P. Bond, of Cambridge, the astronomical observer of the American Academy of Arts and Sciences, discussing the magnetization of the earth; from I. M. Gillin, of the Observatory at Washington; T. D. Graham, of Baltimore; A. D. Bache, belonging to the Coast Survey, and so on. A letter from the secretary of the American Academy announces the appropriation (22 April, 1840) of $1,000 for the purchase of instruments recommended by the Royal Society.

I shall say nothing of records more recent. We are all familiar with the bold advance of modern science, and extracts from the archives relating thereto would be superfluous. Specialization continuously increases. Papers become ever more complicated, each appealing only to a fraction of the scientific world and not at all to the general reader. The change from early times is very great indeed. It is inevitable and it implies success in experiment and deduction. But its effects are serious and must be examined carefully.

These extracts show, I think, that the archives furnish a rich commentary on the history of the period during which the Royal Society has been in existence. They show too that the society has played no small part in the doings which that history records. The new spirit which gave rise to the society demanded that action should be based upon experimental research and however spasmodically the world as a whole has obeyed this new principle, however ignorant men of all kinds, rulers and ruled, have been of the working of the leaven, the change in the ordering of men's activities has proceeded steadily and strongly. It has grown as the roots grow underground, preparing the life of the plant when the time comes for it to flourish. That time is already here, if we may judge by the extent to which natural knowledge is now used in all that men do.

We now observe the flower and the fruit that it bears. As we all know, we have reason both for satisfaction and for anxiety. We do see the happy results of a better acquaintance with nature in a greater freedom from disease, in a richer life, in new opportunities for the exercise of talent, in a wider outlook. On the other hand, the problem of the well-being of the community is still far from complete. Not long ago your American Association for the Advancement of Science met in Richmond to hear a noble address from its president. The very title of his address, "Intuition, Reason and Faith in Science," was an indication of the position from which many of our most thoughtful scientists regard the problem as it stands to-day. From our side of the water we were glad to send Sir Richard Gregory to show that we also are trying to take our bearings for a new advance. We can not stand still, of course; we must go forward, even though the way is not clear. We know the strength of science, we see that it has done great things, and are confident that its powers can be employed with greater and greater success as we give our whole minds to the problem that we have to solve. How shall we ensure the right use of natural knowledge, give full play to its beneficence and prevent its abuse? You and we and, let us hope, all associations of scientific men the world over are of one mind in this matter, and are glad of the strength that unity brings.

The very fact that we share this good-will points to the road that we must take. The good-will that is based on our mutual understanding of what we are striving for is somehow to cover the world. I have not of course the presumption to say that science is by itself to leaven the whole. There are other incentives to cooperation; first and foremost stand the binding forces of pure religion. But the cooperation of the scientists is a new leaven, though it is not the first in the field. It is our own contribution which, if we can make, we must make or we fail in our duty to the world. I assume that we accept the duty.

We can surely conclude, from what we learn in the accumulated accounts of their doings, that the learned societies have not been unmindful of this primary purpose. No doubt in the early days when men collected facts as matters of interest, the recitals to which they listened were to many of them a private benefit only. Yet there were always men of wider vision who saw also the future benefit to their country or the world in the ordering of natural knowledge. The archives of the Royal Society into which I have dipped here and there in order to provide illustrations of my argument show the continuous endeavor of a body of scientists to be of help to their fellowmen. They may not have been always conscious of such an effort; in any community you may find some who are purely selfish. But as a body of men, vivified by those who had in them most of the right spirit, they have played a great part and I believe firmly a beneficent one.

We can not but ask ourselves whether it is possible to say that such and such actions and dispositions of societies like yours and ours have been the dispensers of good, while others are to be set on the opposite side. Some results derived from science are good: some already are bad. Are these antitheses related to similar opposites in our work as scientists?

Most thinkers now agree that we are not responsible for the uses that are made of the knowledge we find. We can not control the strong passions that seize upon discoveries for selfish purposes. The work of discovery goes on and no one can stop it, not even ourselves. The constant demand for knowledge that is required for the solution of problems in health, in industry, in every human activity is so insistent that knowledge increases continuously and rapidly. And even if there were not this practical urge there would be the never-failing curiosity to know more. We must therefore accept the position; we all seek for an understanding of how to make the best of it.

I have referred already to the addresses given recently by Dr. Birkhoff and Sir Richard Gregory. They illustrate a movement which gathers strength. It is based on an anxious determination to find out how the new situation is to be gauged and treated, and in particular, what the scientist may do. There is so much inquiry to be made before an answer can be given to this general question that it would be wrong to anticipate a conclusion. We can only remind ourselves of a few obvious lines of action, which we take in the expectation that the less obvious will become clear.

There is the great question of right exposition. It may be that there are some who would even now disclaim any duty of scientific men in this respect; and certainly there were many who would have done so in the past. If, however, we suppose that natural knowledge and the power which it gives are a common possession of mankind, we ought to make sure that what is found is understood. We can not compel men to make use of science in the right way, but the chance that good use will be made is in a curious way dependent on the ease with which it is stated. If its expression is in forbidding terms, the man who sees no direct benefit from the effort of facing a difficult understanding leaves it alone. On the other hand, the man who is engaged in a fight against his fellows, whether in business or in war, grasps at any advantage that knowledge gives him, if he becomes aware of it. And of late years such men have seen the advantage, whence comes much of our present perplexity. The world is horrified by the development of frightful engines of war. It observes too that a technical invention, based it may be on some new scientific discovery, may throw great industries out of gear and bring misery upon employers and employed. These are obvious evils, and it is not surprising that the proper desire to increase knowledge is supposed to be associated with a tendency, even a desire to make ill use of that knowledge. Also those men of good will who are acquainted with scientific aims and achievements have their own peculiar distress because they know how little is done for the general good, compared to what could be done.

Exposition, therefore, becomes one of our chief concerns. It must be mated necessarily with the understanding that appropriate education can provide. We desire that all men and especially men of good will, and especially also men of good education who are the natural leaders should be aware of what science is doing and can do. A certain surviving distrust based on past misapprehensions has to be cleared away and replaced by cooperation.

I was standing once on the platform of a little upcountry railway station in Australia, with others who had come to share the mild excitement of the arrival of the infrequent train. There was bustle when the train was ready to start, flag waving, bell ringing and cries to stand back. The engine whistled loudly, and went off by itself: the coupling with the train had been forgotten. There was a moment's pause, and then a shout of laughter while the shamefaced officials set out to repair their mistake.

There is something like that in what is taking place to-day. Scientists are so preoccupied with their business of research, naturally so, and in their researches have gone so far that the world has no clear knowledge of the positions that have been reached. We have to see to the coupling and take the world with us. It may seem ungracious to make a statement of this kind when so much is already being done to popularize scientific knowledge. Yet it is to be observed that much of the science which is absorbed by the people lies on planes of lower value. Some that is intended for popular enlightenment is of that kind which seeks to dazzle by the recital of huge numbers. We must, of course, learn how narrow is our knowledge if we limit it to the consideration of spaces of about the same magnitude as our own bodies, or of times comparable with our own length of days. But that is a lesson in humility; the mere staring at big figures is childish if there is nothing more.

There are scientific writings which tend to be mystical and need very careful reading, lest they seem to contain a meaning when in fact they do not. Some of the terms used to describe scientific observations are drawn from the general vocabulary, such as wave, vibration, ray, ether and so forth, and are defined or redefined for the specific purpose. If they are allowed to carry at the same time any unrestricted meaning that can be given to them in ordinary usage an argument which includes them gets out of control and leads to danger.

The observations of natural science, though they have now passed far beyond the range of the unaided senses, have not left the plane in which eyes and ears are accustomed guides. Neither they themselves nor any combination of them rise to a higher plane: that is reserved for conduct, which, however, must take account of them.

The understanding of science that should be general to all men is of a simpler kind. It rests on a knowledge of the elementary laws of nature, so far as we can ascertain them, and an appreciation of their continuous influence upon our lives. It leads to an awareness of the general position, though not necessarily a detailed acquaintance with it. It couples us all together in the desire to learn from nature. We enrich our own lives, and we learn how to enrich the lives of our neighbors; but the great happiness lies in the discovery that there is a world in which we can all work together for the common good, in which there is endless work to be done, and an unselfish purpose can lead us from strength to strength.

Herein lies the finest work of science. Even the relief from pain and disability, the increase both in quality and in quantity of the fruits of the earth, the betterment of all the conditions of life are not the end; there is something higher. It is the mutual service that is rendered when these things are fought for, and the happiness of mutual trust and reliance, and the last great act of virtue, that is to say the sacrifice of self. To quote from Dr. Birkhoff's address: "I would state a fundamental truth about the social level which in some sense is the highest level of all [ranking, that is to say, above four other levels which he described, mathematical, physical, biological, psychological]: the transcendent importance of love and goodwill in all human relationships is shown by their mighty beneficent effect upon the individual and upon society."

Collectively and individually scientists have done great things. Yet their achievements have value of one kind, and the spirit in which they worked has value of another kind; and the latter value is far more to be desired than the former. We may truly say of some of our greatest men of science that the world has gained more from their lives than from their discoveries, and this is so even if their influence on the world is limited to that which the world has been able to perceive. Their discoveries made them famous, but they themselves are better known than their discoveries. Faraday's reverence for truth and unselfish devotion to its acquisition have a higher value than the laws which he established. We gladly admit our debt to Pasteur and to the Curies, and yet the inspiration which we draw from their lives is even better than the results of their work. The world admires Franklin for his discoveries in electricity, yet it respects him more for his wisdom. I might prolong the list, but every one here can do that for himself. In brief the spirit in which knowledge is sought and the manner in which it is used are more important, more real than knowledge itself.

The records of scientific discovery, of the development of the fields of experiment which began three hundred years ago, have shown the growing power of science. The extent of their power is to-day a chief concern; we must, as so many are now trying to do, give anxious thought to its exercise. The power is not actually in the hands of the scientist, though he is deeply interested in its future because he has been and is the occasion of its existence. It may fairly be inferred from experience that the scientist himself will never be a tyrant. His work does not rouse in him the desire to dominate, but rather to assist. Love of accuracy, patience, perseverance, self-denial have been common qualities and necessarily so. These have a place in the general esteem, and therefore have their effect. Most of all the world respects the devotion to service that has so often been found; the warm love of their fellows which has inspired so many to give themselves and their labor without counting the return. We must hope that such a spirit will continue in ourselves, whether as individuals or as societies.

The problems of society and in particular those into which natural knowledge enters so powerfully will long demand a patient examination. But whatever may be the tactics that are developed in the end, it is certain that the satisfactory solution will be based upon moral influence. It is for us, as scientists, to supply the natural knowledge and help in its application, but that is not the complete account of what we have to do. Our effectiveness will depend, as is shown by all human history including our own limited experience, upon the devotion, wisdom and good-will which we bring to our task.

SCIENTIFIC EVENTS

THE ZOOLOGICAL SOCIETY OF LONDON

In a summary of the annual report of the Zoological Society of Great Britain, given in the London *Times*, it is reported that there was a decrease of 130,885, compared with 1937, in the number of visitors to the Zoological Park, London, last year. This is attributed mainly to the September crisis. The total number was 1,816,012. At Whipsnade there was an attendance of 523,345, a decrease of 23,073.

The number of visitors to Regent's Park was the twelfth highest in the history of the society. Admission receipts were £5,628 less than the previous year, and total income amounted to £112,957, a decrease of £12,165. Expenditure was £112,488, a decrease of £5,061, leaving an excess of income over expenditure of £469. Receipts for admission to Whipsnade decreased by £1,077. Income was £33,575, a decrease of £2,421, and expenditure was £27,568, a decrease of £738, giving an excess of income over expenditure of £6,007.

The average strength of the society's collection, excluding aquarium, reptile and insect houses, was 1,035 mammals and 1,846 birds. The animals at Regent's Park consumed 91 tons of hay, 156 tons of clover, 124 tons of horseflesh, nine tons of monkey nuts, 12 tons of bread, 244,649 bananas and 4¼ cwt. of honey.

The aquarium was visited by nearly 15 per cent. of those who entered the gardens. The visitors numbered 283,248, compared with 271,933 in 1937. The increase was largely due to the reduced charge of 6d. on Saturdays, instituted during the year.

In September, it is stated, a scheme was worked out for measures in case of war or other emergency. This involved the conversion of basements into air raid shelters and the removal of valuable books and documents and the families of the staff to Whipsnade.

THE TRANSFER OF DIFFICULT ALPINE PLANTS MADE AT WASHINGTON ARBORETUM

Although the Washington Arboretum at Seattle has been established for less than three years it is producing results that are attracting the attention of both layman and scientist. Thousands of plants have been propagated that are now being placed in permanent locations on the grounds where they will be kept under observation for developments of scientific and educational value.

A significant accomplishment has been the transfer, in one year, of alpine and subalpine plants from their natural altitudes to sea level with no loss of vigor and with no apparent change in character. Three notable instances of successful transfer were *Campanula piperi,* a miniature evergreen member of the Campanulaceae; *Lewisia tweedyi,* the largest and most beautiful of the Lewisia tribe, and *Douglasia dentata,* a rose-colored evergreen member of the Primulaceae. The domestication of these three little known but valu-