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THE CONTRIBUTIONS OF COUNT RUMFORD AND MICHAEL FARADAY TO THE MODERN MUSEUM OF SCIENCE[1]

By Sir WILLIAM BRAGG

DIRECTOR OF THE ROYAL INSTITUTION AND OF THE FARADAY RESEARCH LABORATORY

I AM told that I must say something about the "Diary of Michael Faraday," a book which we treasure at the Royal Institution. I would like to say a word or two about that at first but, as a matter of fact, I hope you will allow me to use it rather as a text for a somewhat larger subject, that is, the work that you and we are jointly trying to do.

Faraday's diary is indeed a most interesting document. It is contained in seven or eight large volumes of manuscript which have never been published. It is a record of his doings day by day. All his experimental work was collected by him from time to time and students in electricity know these papers and books of his quite well. But the diary is something more—it is the record day by day of what he thought, what work he was doing. It is a very human, very interesting document. He almost talks to us as he sits by night recording what happened to him during the day. Sometimes there is delight at having achieved success in an experiment, and sometimes a little fit of depression, as when he says, "So after all, that which I thought was a new discovery was only an accident." Sometimes he deliberately writes out an ordered plan for his next work. He uses some such phrases as: "So, if this takes place, the consequences should be. . . . Then I must try. . . ."

I assure you it is a most interesting book, and I trust the Royal Institution will succeed in publishing part of it next year. And then I hope that you all

[1] Address given by Sir William Henry Bragg at a science luncheon given in his honor at the Hotel Astor on May 27, 1930, by the Museums of the Peaceful Arts, the American Institute and the New York Electrical Society.

will feel the same charm that we do who have read it. The work that Faraday did is important to us in many ways because it is part of a great movement that is now beginning to take shape in the world.

If you would see the very beginnings of this movement, you will have to go back 250 years or more, to the time when such societies as the Royal Society of London first began to draw people's attention to the wonders of the world about them.

The first fellows of the Royal Society in London were just like a lot of school boys. As you look over the early volumes of the Royal Society *Transactions,* what will delight you most is the curious jumble of things submitted. Here is a man who gathers information respecting the ventilation of mines in Belgium. On the next page you will find a paper describing an animal monstrosity, etc. That was the Science Museum in those days.

If you step forward one hundred years or rather more, you come to Benjamin Thompson. Benjamin Thompson was a man who taught school in Rumford, Massachusetts—that was why he afterward assumed the particular title "Count Rumford." You will remember that in the time of the troubles between the colonies and the mother country, Rumford espoused the cause of the latter and was obliged to leave America.

Rumford was a strange man who believed in his heart in benevolent despotism. He went to England first and made his name both as statesman and as scientist. He afterwards went to Bavaria and took service with the Elector. He quickly rose to a position of considerable distinction and felt he was possessed of so much power that he carried out a most remarkable feat. He cleared the town of Munich of its beggars. Europe was overrun at that time, and in Munich they were estimated to be five per cent. of the whole population. He bought a building outside of the city, furnished it and on January 1, 1790 (which was Beggars' Day), Thompson so arranged with police officials of the city that, as each beggar put out his hand for alms, he was kindly but firmly led away to the Town Hall. There he was told that at the new institution there was food for him and warmth and liberty to work if he wanted it. It is hard to believe that such arbitrary measures could be successful, but the fact remains that he made the institution remunerative and its inmates happy, if we may believe his biographer.[2] That was indeed benevolent despotism.

He had the first ideas of applying scientific results to the needs of every-day life and he wrote several pamphlets on the subject. There are copies of them in this country. These pamphlets deal with what a scientific museum should be, how it should be conducted, what should be in it, what might be expected of it. He was a master of detail, and when you read over what he says, you realize you could not have a better guide if you wanted to set up a museum. He said, for example, that qualified instructors should be present to explain the models, and that is recognized now as one of the important features of a modern institution.

In a famous museum in Munich, where Rumford did his work, this principle is carried out in detail, and in the Science Museum of London there are hundreds of operating exhibits and the staff members are recognized generally as men of authority in their respective fields.

No doubt this is perfectly right. It is absolutely necessary to conduct a museum in this way. It is the best way to catch the public eye. I remember when I was a professor in Adelaide, we were to receive a visit from a member of Parliament. In connection with drawing his interest to our work, I remember the advice given me by a shrewd friend, "Mind you have something that buzzes or goes around." As a matter of fact, people do like to see things move.

Every year for more than a century Christmas lectures for children have been given at the Royal Institution. I notice that boys and girls like best to see demonstrations of mechanical principles, to see things working. We are all children still, and we do enjoy a science museum where there are working models and demonstrations of them. I think that the technique of a science museum is being gradually evolved. The operating model alone will not suffice, but I do regard it as one of the most fundamental means of instruction that we have.

I take it you represent these societies which are so interested in popularizing natural phenomena. We are linked together in one great endeavor to make the presentation of knowledge understood by the people and useful to them. That is the elemental feature.

Benjamin Thompson had great schemes. To those schemes, as a matter of fact, I owe my position, because it was under his scheme that the Royal Institution was organized in 1799. He was perhaps ahead of his time in creating an institution of working exhibits for public education. There is still a room that is called the model room. He called together various workmen—a plumber, a carpenter, a tinsmith, etc. He brought his various friends together to help in forwarding this idea. There was hardly sufficient understanding as to what might be done, or perhaps it was too ambitious, but at all events the scheme fell to pieces and he went back to Bavaria, but others remained behind, changed its purpose and went ahead.

Rumford always had the idea that there should be lectures, and certainly lectures are a very valuable ad-

[2] Rumford's life is described by Ellis in a book written at the instance of the American Academy of Arts and Sciences in Boston.

junct. Also the Franklin Institute, to which the Royal Institution is akin, has made great progress in this direction. To some extent these lectures have filled up the gap which Rumford saw but which are still to be perfected by institutions such as mine and yours. In our way we have tried to do it by having every week a discourse by some one who has really done something. He may have discovered something in chemistry or physics or built some bridge or discovered some historical remains, but the point is, he must have done something, and he lectures on that subject to people who are all interested in the progress in science and discovery.

I can not do better than to quote the directions given to the lecturer: He must speak on his subject to people who are interested in other subjects. He must not use technical terms which are not readily understood by all. It is a sort of liaison: an attempt to bind all the sciences together. The lectures have been a success and here I want to go back to Faraday.

This beginning by Rumford became an institution where research was carried on. But in those days systematic research was entirely new, and it was Davy and Faraday, who succeeded him, who were largely responsible for showing what research was and how it should be conducted. In that way the Royal Institution in London came to do scientific work that has played a great part in the world.

I won't attempt to describe what Faraday did because the subject is too great. What Faraday did is the foundation of all modern industry. He discovered the principle upon which the law of electrical engineering is built. He discovered the laws connecting electrochemistry and electricity, etc. I will give you a curious instance of how science develops into something at which everybody wonders.

One Friday evening a famous scientist was to give a lecture before the society and that afternoon Faraday spent with him going over the experiments, but when the evening came, the scientist had lost heart and never appeared. What could Faraday do? He went into the lecture room and went over the experiments as well as he could. When he had finished he began to pour out some of the thoughts that had been in his mind and when he had finished with this the subject had almost grown as he spoke. Afterwards he wrote a little paper, "Thoughts on Ray Vibrations," and this paper was, in fact, the starting-point of certain of his own researches into the electromagnetic theory and the foundation of the electromagnetic work of Maxwell and from that came the work of Hertz and from that came the achievements of Marconi and the modern wireless telephone.

Faraday's work was extremely fundamental and his work meant so much because he saw that experiment could draw together all the physical forms of the world. There is a certain passage in his works where he speaks of electricity, voltaic and static, gravity, heat, cohesion, magnetism, etc.—a whole list of different physical forces and of his hope of coupling them all together. In a way his life work might be looked upon as an attempt to link them all up, for he was convinced that they were connected, and I may prove and illustrate my point by citing the names you give certain fundamental discoveries.

Faraday was the first to discover the principle of electromagnetic induction. You talk now of the principles of electromagnetism. He saw the connection between magnetism and light. We talk of magneto-optics. He saw the connection between electricity and chemistry. We talk of electrochemistry. It was that unity in which he believed—the unity of all nature. He lifted science above that which Rumford and his previous workers had conceived.

As time grows and the horizon widens, we see that the first views of what science does are greater now. We are all committed to the attempt to try to bring it to the service of mankind. It is a great enterprise and we only see dimly now what can be done, but we do hope to do much. In the attempt to explore the wonders of the world, to add beauty where people did not see beauty before, we are doing something for the service of mankind.

Robert Bridges, in the last great work of his, has astonished us by its beauty and its greatness. If you read "The Testament of Beauty," you will find that he has expressed for us the beauty of science. He talks of the influence of dreadful war and he speaks of the time when science will have brought many together into peace through common understanding of the unity and beauty of the world. He speaks of the time when

> War faln from a trumpeting vainglory to a crying shame
> Stalks with blasting curse branded on its brow.

Now you see that what we are aiming at is such a development of science, such a development of the wonders of the world, that we may lose all animosities in thought and understanding. That we may see the knowledge of the world, and all that is in the world, is a great thing at which to aim. In science there is no religion, but it is the act of religion. If we are religious at all in the deepest sense, we must try to bring all the good we can into the world to the service of man, and that is the great work we are all permitted to do.

I feel very much honored that you allow me to come here to-day and speak on that service in which we all feel deeply.

SUGGESTIONS OF COUNT RUMFORD[3]

In the prospectus of the Royal Institution of Great Britain in 1800 occur in part the following statements of Count Rumford representing his ideas for the formation of a public institution for the diffusion of knowledge and for facilitating the introduction of useful mechanical inventions and for bettering the condition of the poor:

The completest working models or constructions of the full size will be provided and exhibited in different parts of this public repository, of all such new mechanical inventions as are applicable to the common purposes of life.

Every consideration unites in showing how highly important it must be to the progress of real improvements to have some general collection of useful mechanical contrivances, constructed on the most approved principles and kept constantly in actual use, to which application can be made as to a standard, in order to determine whether the failure of experiments be owing to errors in principle, or to the mistakes of workmen employed in the construction, or to those of the servants intrusted with the management of the machinery.

How useful, also, would such a repository be for furnishing models and for giving instruction to artificers who may be employed in imitating them!

When we read the proposals of Count Rumford as to the organization of the Royal Institution, we see that we can have hardly a better guide to-day for founding a museum of science and industry than his suggestions of one hundred and thirty years ago.

PROPOSALS, ETC.

The two great objects of the Institution being the speedy and general diffusion of the knowledge of all new and useful improvements, in whatever quarter of the world they may originate, and teaching the application of scientific discoveries to the improvement of arts and manufactures in this country, and to the increase of domestic comfort and convenience, these objects will constantly be had in view, not only in the arrangement and execution of the plan, but also in the future management, of the Institution.

As much care will be taken to confine the establishment within its proper limits as to place it on a solid foundation, and to render it an ornament to the capital and an honour to the British nation.

In the execution of the plan, it is proposed to proceed in the following manner:

A place having been fixed on by the managers for forming the Institution, spacious and airy rooms will be prepared for the reception and public exhibition of all such new and mechanical inventions and improvements as shall be thought worthy of the public notice, and more especially of all such contrivances as shall tend to increase the conveniences and comforts of life, to promote domestic economy, to improve taste, or to promote useful industry.

The most perfect models of the full size will be provided, and exhibited in different parts of this public repository, of all such new mechanical inventions and improvements as are applicable to the common purposes of life.

Under this head will be included:

Cottage Fire-places, and Kitchen Utensils for Cottagers.
A complete Kitchen for a Farm-house, with all the necessary Utensils.
A complete Kitchen, with Kitchen Utensils, for the family of a gentleman of fortune.
A complete Laundry for a gentleman's family, or for a public hospital, including Boilers, Washing-room, Ironing-room, Drying-room, etc.
Several of the most approved German, Swedish, and Russian Stoves, for heating rooms and passages.

In order that those who visit this establishment may be enabled to acquire more just ideas of these various and mechanical contrivances, and of the circumstances on which their *peculiar merit* principally depends, the machinery exhibited will, as far as it shall be possible, *be shown in action*, or in *actual use;* and with regard to many of the articles it is evident that this can be done without any difficulty, and with very little additional expense.

Open Chimney Fire-places on the most approved principles will be fitted up as models in the different rooms, and fires will be kept constantly burning in them during the cold season.
Ornamental as well as economical Grates, for Open Chimney Fire-places, will also be exhibited; as also
Ornamental Stoves, in the form of elegant Chimney-pieces, for halls, drawing rooms, eating-rooms, etc.

It is likewise proposed to exhibit *working models*, on a reduced scale, of that most curious and most useful machine, the steam-engine.

Of Brewers' Boilers, with improved Fire-places.
Of Distillers' Coppers, with improved Fire-places and improved Condensers.
Of large Boilers for the kitchens of hospitals, and of Ships' Coppers, with improved Fire-places.

Farther, it is proposed to exhibit, in the repository of the Institution:

Models of Ventilators for supplying rooms and ships with fresh air.
Models of Hot-houses, with such improvements as can be made in their construction.
Models of Lime-kilns, on various constructions.
Models of Boilers, Steam-boilers, etc., for preparing food for cattle that are stall-fed.
Models of Cottages on various constructions.
Spinning-wheels and Looms, on various constructions, for the use of the poor, and adapted to their circumstances, together with such other machinery as may be useful in giving them employment at home.
Models of all such new-invented Machines and Implements as bid fair to be of use in Husbandry.
Models of Bridges, on various constructions; together with *models of all such other machines and useful instruments as the managers of the institution shall deem worthy of the public notice*, and proper to be publicly exhibited in the repository of the Institution.

[3] Taken by F. C. Brown from Volume IV of "The Complete Works of Count Rumford," as published by the American Academy of Arts and Sciences in 1870–75.

It is proposed that each article exhibited should be accompanied with a detailed account or description of it, properly illustrated by correct drawings.

In order to carry into effect the second object of the Institution, namely, *teaching the application of science to the useful purposes of life,* a lecture-room will be fitted up for philosophical lectures and experiments; and a complete *laboratory and philosophical apparatus,* with the necessary instruments, will be provided for making *chemical* and other *philosophical experiments.*

In fitting up this lecture-room (which will never be used for any other purpose than for giving lectures in Natural Philosophy and Philosophical Chemistry), convenient places will be provided and reserved for the subscribers; and care will be taken to warm and light the room properly, and provide for a sufficient supply of fresh air, so as to render it comfortable and salubrious.

In engaging lecturers for the Institution, care will be taken by the managers to invite none but men of the first eminence in science to officiate in that most important and most distinguished situation; and no subjects will ever be permitted to be discussed at these lectures but such as are strictly scientifical, and immediately connected with that particular branch of science publicly announced as the subject of the lecture. The managers to be responsible for the strict observance of this regulation.

In case there should be places to spare in the lecture-room, persons not subscribers will, on the recommendation of a subscriber, and on paying a certain small sum to be determined by the managers, be permitted to attend the public lectures, or any one or more of them.

Among the various branches of science that will occasionally be made the subjects of these public lectures may be reckoned the following, viz. These lectures will treat:

Of Heat, and its application to the various purposes of life.
Of the combustion of Inflammable Bodies, and the relative quantities of Heat producible by the different substances used as fuel.
Of the Management of Fire and the Economy of Fuel.
Of the Principles of the Warmth of Clothing.
Of the Effects of Heat and of Cold, and of hot and of cold winds, on the human body, in sickness and in health.
Of the Effects of breathing vitiated and confined air.
Of the Means that may be used to render Dwelling-houses comfortable and salubrious.
Of the Methods of procuring and preserving Ice in Summer; and of the best principles for constructing Ice-houses.
Of the Means of Preserving Food in different seasons and in different climates.
Of the Means of cooling Liquors in hot weather, without the assistance of ice.
Of Vegetation, and of the specific nature of those effects that are produced by Manures; and of the Art of composing Manures, and adapting them to the different kinds of soil.
Of the Nature of those changes that are produced on substances used as food in the various processes of cookery.
Of the Nature of those changes which take place in the Digestion of Food.
Of the Chemical Principles of the process of Tanning Leather; and of the objects that must particularly be had in view in attempts to improve that most useful art.
Of the Chemical Principles of the art of making Soap; of the art of Bleaching; of the art of Dyeing; and in general of *all the mechanical arts,* as they apply to the various branches of manufacture.

BIOCHEMICAL RELATIVITY

By W. H. MANWARING, M.D.

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ABOUT twenty-five years ago there were introduced into certain fields of physical science radically new basic concepts, particularly in reference to atomic structure and radiant energy. Within one decade the general acceptance of these new hypotheses rendered obsolete a thousand previous conscientious researches. For two decades the new theories have been the accepted basis for a hundred hitherto impossible practical applications. To-day we are apparently at the beginning of a similar basic revolution in certain biological sciences, particularly in those fields of physiology and biochemistry bearing on the phenomena of infection and bodily resistance.

Within the last five years there have been introduced in America, Germany, Russia, France and Czecho-Slovakia radically new immunochemical hypotheses, which, if generally accepted, will render inconclusive half of forty years' accumulated immunological literature. The suggested theory of biochemistry relativity casts doubt on a hundred current therapies, challenges a score of physiological orthodoxies, suggests a new perspective in ecology and genetics, has invaded the field of educational psychology and has already led to at least one previous chemical impossibility.

I

The theory of biochemical relativity was developed to explain the origin and nature of "specific antibodies." Demonstration of the existence of highly specialized biochemical defenses in the bloods and tissue fluids of convalescent and artificially immunized animals dates from the closing decade of the nineteenth century. Serum transfer of acquired immunity, serological conviction for murder, test-tube determination of illegitimacy and cutaneous tests for hereditary idiosyncrasies are a few typical applica-