can lead to confusion between "authority and the oracle," which is perilous to scientific work. A library is not merely a hall of books but a hall of records of human experience and thought, where one may learn the path along which man has toiled and may discover guiding and liberating influences for the future.

Clinical investigation takes a variety of forms. The aim should be to undertake fundamental problems and to appreciate that progress in the clinic often owes its origin to the fields of pure science. The studies are often of a collective nature, as in the evaluation of clinical data, the evaluation of new procedures or in the correlations of chemical and pathologic information. Proper statistical methods must be employed and standard deviations and probable errors calculated. The descriptive discipline of nosography—the painting of accurate pictures of disease—is a useful guide to keep experimental procedures from going astray. This type of work may depend on the good fortune of observing several cases and not on planned investigation. There is need for more accurate work of this sort especially concerning initial symptoms and the natural history of long-lasting chronic conditions. Controlled observations of human pathologic physiology is the nature of many of the studies of the clinical investigator. The question of the origin or cause of disease is of unusual importance to study. Therapeutics, which is linked with pharmacology, is essentially an experimental science and will always have experimentation on man for its chief basis. The action of drugs always needs evaluation. The object, however, is to study the human body and not drugs *per se,* and one method of doing so systematically is by means of its reaction to chemical and physical agents.

The control of experimental conditions in human beings is crude as compared to the utmost rigidity in the control of the worker in pure science, so that data of observations may be only qualitative or but crudely quantitative. One of the many variable factors is dependent on the fact that the human being has a soul and highly organized nervous system. His emotional reactions, worries, jealousies and the like and his reactions to one or more persons can not only lead to illness but affect the functions of organs. The medical-social, psychological, economic and allied aspects of individuals can be investigated with profit. The field is a difficult one for reliable scientific study, because it involves all the complexities of human life. Even so, a considerable fraction of the successful care and treatment of patients and the prevention of much illness is to be identified with the proper consideration of their medical-social problems. A list of the studies a clinician may pursue is of little value. It is more significant to realize that a prepared mind, well-planned scientific observations and the taking of infinite pains will lead to success, and that important original contributions often are made which require only simple technique and clinical wisdom.

The clinical investigator in his search for truth is not to be thought of as a lone worker or as a man sharply separated from other types of doctors. A close relationship with practitioners, specialists, pure laboratory investigators of many types is mutually beneficial. The men in this institute, like investigators elsewhere, naturally realize that assistance may be obtained from a wide variety of divergent sources and that science is not bounded by the walls of any one institution. There are no sharp lines of demarcation between one medical interest and another or between medicine and a variety of disciplines. Cross-fertilization at the border lines of knowledge can serve to develop new information. The advancement of learning can not be made in water-tight compartments. Modern developments have permitted team work in scientific fields to be much more general and prolific where before isolated efforts were the rule. Cooperative investigations between physicians, scientists and all types of scholars trained in different ways as well as between men in different institutions can enhance knowledge concerning the treatment and prevention of disease and the happiness and progress of a people. Such cooperation when spontaneous is fruitful, but when compelled it may be sterile.

More fundamental than the actual discoveries being made to-day is the preservation of the right to engage in research. If all governments, races and individuals would hold the same high ethical view-point of life that Dr. Squibb did, there would be no murmurings of intolerance to intellectual freedom. Security and happiness have profound beneficial effects on the character of intellectual work. As time passes by we must always be alert to adapt ourselves to changes and realize that to understand the present we must look both towards the past and towards the future.

BIOLOGY AND INDUSTRY IN COOPERATION[1]

By Professor AUGUST KROGH

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IT is a great pleasure as well as a great honor to assist at the inauguration of these laboratories, which represent a very important step forward in the ever closer cooperation between biological science and biotechnical industry.

[1] Presented at the dedication exercises of the Squibb Institute for Medical Research, New Brunswick, N. J., on October 11, 1938.

That industrial development is deeply influenced by scientific discoveries has long been recognized in the case of physics and chemistry, and I need only mention such names as Faraday, Oersted and Hertz and the electrical industry to make it clear to you how enormous the influence has been.

The influence of biological sciences on what I would call biotechnical industries is a later development, but not less profound, and the relations between industry and biological science is, as all good and durable relations should be, by no means one-sided, but mutual, science deriving extremely valuable help and stimuli from the industries. I propose to discuss briefly such mutual relationships as illustrated by conditions in Europe and I shall go a little more into the relationships in Denmark to which I can claim some first-hand knowledge.

The preparation of biological products for human use and consumption is as old as civilization itself. The fermentation of sugars was utilized before the dawn of history, products of the silk industry in China reached the western world by trade centuries before any European had ever visited the Far East. It is a cause for wonder how many potent drugs were discovered by a process of practically unconscious trial and error through many generations in remote antiquity.

Until about a century ago the preparation of biological products, including drugs, took place largely as home industries and on a small scale, while the manufacturing processes were the results of tradition created by practical experience. Mishaps were very common, but their effects local and as a rule not very serious. There were as a matter of course large variations in the fermentations underlying the productions of wine and beer. Bacteria would occasionally make their appearance and spoil the products completely, and diseases would attack the plants which supplied the raw materials. Large variations occurred in the potency of drugs, but were rarely discovered because of the lack of precision with which their effects could be determined.

The difficulties became apparent and their seriousness appreciated when attempts were made to work on a large scale, and science was called in to help solve these difficulties. The work of Louis Pasteur furnishes one of the oldest and certainly the most brilliant example of what science could do to help biotechnical industries like the production of wine, beer and vinegar and, the most spectacular of all, his saving of the French silk industry in the years 1865–71. In Denmark the scientific work in the interest of agriculture dates back to about the same time and has been vigorously prosecuted ever since.

Assistance rendered by science to industry was necessarily the first step to make industry interested in the development of science and the mutual help has naturally taken many different forms.

A close and fruitful cooperation between science and pharmaceutical industry is illustrated in the history of the firm of Merck at Darmstadt. The apothecary Heinrich Emanuel Merck started a production of purified drugs, especially alkaloids, on a comparatively large scale in 1827. He was the owner of the Angel Pharmacy, which had at that time been in the possession of the family during five generations and for over 150 years. He was a very good chemist, a close friend of Liebig, and had himself worked out methods for the isolation and purification of several alkaloids. It is a very remarkable fact, speaking highly for his scientific spirit, that he did not keep his methods secret, but published his results in sufficient detail to allow others to benefit by them.

The firm was carried on as a family undertaking. At the present time it has, under the direction of the great-grandsons of Heinrich Emanuel, grown into a huge concern and is doing a large amount of scientific work in the interest of the firm. They have very large laboratories for the synthesis of substances. They have pharmacological, chemotherapeutic and bacteriological departments for the exhaustive study of the action of their preparations on the animal and human body, for the control of sterility, and so on. An important new branch is concerned with the application of micro-organisms for the production of new substances by their controlled activity.

H. E. Merck a hundred years ago kept up a considerable correspondence with scientists in Germany and elsewhere, both giving and receiving suggestions and advice, and out of this has grown the "scientific department" of the present firm, whose chief business it is to keep in touch with practice and with independent science. They receive and examine all kinds of hints and suggestions with regard to the activity of the firm, trying to meet the wishes of individual workers, and they also take care of all inquiries, general or special, and supply information not only from knowledge directly available in the minds and memories of scientists in the employ of the firm, but in many cases they also undertake a search of the literature and even go to the length of actual experimentation to satisfy inquirers. The value to independent workers of thus having at their disposal the accumulated experience and knowledge of experts can scarcely be overestimated.

I would like to emphasize the services rendered to science by the firms supplying pure chemicals and pure drugs. It does not seriously detract from these services and it shows the difficulty of the task that in spite of all care the purity obtained is not always suffi-

cient. There is a recent example studied by Güntelberg in Denmark, where it was found that a content of 0.05 per cent. bromine present in analytic chloride preparations from a number of firms had disastrous results in electrometric pH measurements, and a few years ago the presence of minute traces of silver in sodium chloride made Ringer solutions definitely poisonous for fish hearts.

The firms are, as a rule, ready to render assistance when new substances are desired for experimental purposes, and I would like to mention a point where demands are being made which, if they can be fulfilled, will prove of very great value to experimental biochemistry. I refer to the production of organic substances like amino acids and lipoids containing deuterium instead of hydrogen in certain selected positions in the molecule. If such substances, which are, as we call it, "labeled" by the content of deuterium, but chemically identical with those containing ordinary hydrogen, can be made available they will be extremely useful in the study of intermediate metabolism.

It is of course impossible to mention here all the firms which by the work in their own laboratories have rendered services of great value to biological science, and I am fully aware that my selection is largely arbitrary and determined by my personal interests. I can not refrain, however, from referring to the brilliant work by Stoll, Rothlin and their collaborators in the firm of Sandoz. Unlike most other firms, they have cultivated a restricted field and made fundamental contributions to the chemistry and pharmacology of the alkaloids from Secale and the glycosides from Digitalis, Scilla and Strophanthus.

I would also mention the work done in the laboratories of Hoffman la Roche on the synthesis of vitamins and the work done in the laboratories of the firms Ciba, Organon and especially Schering, on the isolation, determination and synthetic preparation of sexual hormones as well as their contributions towards the clearing up of the terribly complicated problems relating to the pituitary hormones. To the work on sex hormones also the laboratories of Danish firms (Leo) have made notable contributions, and I want to emphasize the point that in the academic study both of vitamins and of hormones the laboratories of commercial firms have played a very conspicuous part and greatly accelerated progress.

So far as I have been able to ascertain the laboratories mentioned are all rather intimately connected with the firms supporting them, and each works ultimately in the interests of the firm. Certain leaders of industry, however, have been broad-minded and deep-sighted enough to create and support laboratories for fundamental research having for their avowed object the progress of science and the furtherance of industry generally without regard to the interests of their own firm. The example best known to me is the Carlsberg Laboratory, founded by the proprietor of the Carlsberg breweries, J. C. Jacobsen, in Copenhagen and almost at once handed over, together with the necessary capital, to an independent trust, the "Carlsberg Foundation," the members of which were selected by and among the Danish Royal Society of Science and Letters.

The Carlsberg Laboratory began work as early as 1876. The main object was stated in the words, "To provide a scientific basis, as complete as possible for the operations of malting, brewing and fermentation." At the same time the leaders were requested to maintain a high scientific standard by other studies and investigations, and it was expressly laid down that "No result of theoretical or practical importance may be kept secret." The work was to be supervised by a board consisting of three members of the Carlsberg Foundation representing natural sciences and two others, of which it is customary that one represent the Carlsberg breweries. The money allotted to the Carlsberg Laboratory was at first about $10,000 yearly and is now about $50,000.

The first leaders of the Carlsberg Laboratory were Johan Kjeldahl and Emil Chr. Hansen. Kjeldahl made his name a household word in chemical, biological and biotechnical laboratories all the world over by his method of nitrogen determination, and he made also very important studies of carbohydrate splitting enzymes. Hansen is chiefly known by his studies of yeasts leading to the adoption of pure strains of yeast derived from one single cell in the brewing and other industries. The successor of Kjeldahl was S. P. L. Sörensen, whose work on pH definition and determination is too well known to need any reference.

When Jacobsen died in 1887 the Carlsberg breweries were handed over to the Carlsberg Foundation and their income became available for the support of science, letters and art in Denmark, including the maintenance of the Carlsberg Laboratory. The benefits to science have been enormous and on the whole the arrangement has worked well, but I have grave doubts regarding the general wisdom of selecting by and from a body of scientists the leaders of a very large industrial undertaking.

The history of the Wellcome trust in England is in important respects very similar to that of the Carlsberg Foundation. The Wellcome Research Laboratories were established in the beginning of this century by the proprietor of the Burroughs Wellcome firm of manufacturing chemists to undertake medical research of a fundamental nature, and very important work was done under the leadership of Dale on the ergot alkaloids and on anaphylaxis. In 1924 the Wellcome

Foundation was established to take over the business and to keep up the different Wellcome laboratories and museums, and on the death of Sir Henry Wellcome in 1936 the whole estate was placed in trust for the benefit of medical science not only in England but in the world. I understand, however, that in this case the firm is carried on independently of the trust, which only disposes of the income.

This arrangement is somewhat similar in principle to another Danish experiment in cooperation between science and industry. Shortly after the discovery of insulin we undertook under a license from the University of Toronto the manufacture of insulin, primarily for the Scandinavian market, and arrangements were made to make this undertaking a public trust, the proceeds of which should be devoted to the furtherance of physiology and clinical endocrinology.

Under the leadership of Dr. Hagedorn the Nordisk Insulin Laboratory has grown into a fairly large concern, maintaining its own hospital for the study of endocrine disorders and fulfilling, I believe, an important function in keeping insulin prices in Europe at a comparatively low level. The surplus is handed over to the Scandinavian Insulin Foundation, composed of clinicians and physiologists from Denmark, Finland, Norway and Sweden, who distribute grants in aid of research. I think this a fair way of letting the exploitation of a scientific discovery help to further scientific research, but of course everything depends upon finding the right man to make such an undertaking a success.

With the inauguration of the Squibb Institute for Medical Research which we are dedicating to-day the firm of E. R. Squibb and Sons enters upon what constitutes in my opinion the highest level of cooperation between science and industry so far attained. In this case also a great deal depends upon finding the right man and I wish to express my confidence in my old friend, Dr. Harrop, who will be the leading spirit on the scientific side.

In the firm conviction that great benefit will accrue both to the firm, to the industry generally and to our beloved science I wish to express the gratitude of biology and to offer my heartfelt congratulations.

OBITUARY

RAYMOND H. TORREY

RAYMOND H. TORREY, one of the nation's leaders in the field of outdoor recreation and conservation, died at his home in Queens, Long Island, on July 15, 1938, upon his fifty-eighth birthday. Mr. Torrey was born in Georgetown, Massachusetts, and was a son of Captain Grafton F. Torrey, of Deer Island, Maine. He embarked upon a newspaper career at the age of sixteen and worked in Springfield, Massachusetts, until 1903, at which time he went to New York City to join the City News Association. At one time, he was night city editor of the *New York American* and the *New York Tribune.*

From the very beginning, Mr. Torrey showed a native interest in the out-of-doors and through the years gathered a great deal of information concerning history, geology and botany. At the time of his death, he was president of the New York Torrey Botanical Club and had become nationally known as an authority on lichens, having published a number of papers upon the subject, especially in the New York Torrey Botanical Club bulletins.

He was the organizer of the New York and New Jersey Trail Conference, and secretary of that conference for many years. He was also secretary of the Association for the Protection of the Adirondacks, secretary of the American Scenic and Historic Preservation Society and a member of the board of managers of the Appalachian Trail Conference, which organization directed the building and maintenance of the Appalachian Trail, a mountain footpath leading from Maine to Georgia. Mr. Torrey was also a former secretary of the New York State Council of Parks and former field secretary of the National Conference on State Parks. He was a member of the board of managers of the New York Botanical Garden, a member also of the American Museum of Natural History, the American Geographical Society, the American Association for the Advancement of Science, the Appalachian Mountain Club, the Green Mountain, Adirondack Mountain, Fresh Air and Tramp and Trail Clubs.

As field secretary of the National Conference on State Parks, Mr. Torrey traveled throughout America and reported upon the progress of parks in this country. His report entitled, "State Parks and Recreational Uses of State Forests," published by the conference in 1926, was one of the first comprehensive surveys of our park systems. As the principal author of "The New York Walk Book," together with Dr. Robert L. Dickinson and Mr. Frank Place, Mr. Torrey set before the people of metropolitan New York an outstanding compendium of recreational opportunities. The book has been reprinted several times and has been the means of informing countless citizens regarding various objectives along many trails.

Mr. Torrey's column, "The Long Brown Path," was published for many years in *The New York Post.* This newspaper column served to inform interested readers of opportunities to study botany, geology and zoology out-of-doors, and also helped them to realize