(5) Sufficient time to reach stable conclusions.
(6) Living salaries for workers.
(7) A central organization to aid investigations and correlate results.
(8) A definite and comprehensive policy.

BYRON CUMMINGS
UNIVERSITY OF ARIZONA

## COOPERATION IN RESEARCH

RECENTLY while driving to Enfield Falls, near Ithaca, N. Y., I passed a man trying to push a heavy sedan out of a ditch, where the rear wheel had securely lodged itself. My companion and I returned and offered to help him. We went behind the car intending to push while the owner of the car would pull with his engine, but to our surprise, he also placed himself at the rear intending to help us. Not until I suggested that he could do infinitely more good at the wheel did he realize that pushing alone would never dislodge him. Jumping into the car, he had scarcely started the engine when he was on the road again.

We have here a striking example of two types of cooperation, as well as an illustration of their respective merits. Had there been sufficient help, pushing alone would have been enough, but how much easier it was for us all as it was done. Pushing alone might be regarded as cooperation among men of the same science, whereas pushing and pulling together might be regarded as a cooperation between allied sciences. Although the latter offers the richest rewards, yet in practice it is the most difficult to bring about. It is being done on the industries, but, unfortunately, few workers in our universities have attempted it. Some who have tried it have met with failure, because the companion scientist was not interested. President Farrand, in his address of welcome to the delegates of the Optical Society of America on the occasion of their recent meeting in Ithaca, deplored the existence of departments so highly specialized as to offer a real problem in administration. He no doubt referred to the feeling on the part of a given science that it was the most important, and that its annual appropriation was of more consequence than that of another science.

For convenience we may classify cooperation under three headings, namely, among men in the same science, among men in allied sciences, and cooperation in the form of loaning apparatus.

We may further subdivide cooperation among men in the same field into three classes, that between men in the same department, between men in different institutions, and between the universities and the industries. In the same way we may classify the second type of cooperation, that between different sciences, as cooperation between different departments of the same institution, either university or industry, and between university and industry. Cooperation by means of apparatus may take various forms. It may consist of an outright loan, or permission to use apparatus without removal. The industrial worker might be given access to the university laboratories for trying out new methods on a small scale, while the university worker might be given access to the industrial plant for large-scale experimentation.

Let us first consider the possible drawbacks. As a rule, we would probably find that pioneer work in a field such as that of Maxwell or of Gibbs would not lend itself to cooperation, because of its being a generation ahead of the rest of the world. Still we must recognize the existence of such work as the Michelson-Morley experiment, which was in reality the highest type of cooperation between scientists in allied fields. Most of our cooperation must however needs be along the line of working out details of known phenomena.

We would also no doubt find that we would become more specialized than ever, and as a result, less capable of carrying on independent research. This is indeed the tendency in some of the large industrial laboratories, although fortunately not in all. As a rule it is considered best that the men know little beyond their own particular problem, since in that way trade secrets are not so easily lost. This may seem a bit exaggerated, but I need only say that recently I wished to be better posted on a given scientific process and wrote to the director of one of our large industrial research laboratories, which used the process, for the latest literature references on the subject. He referred me to several books some fifty years old, but said that they were not up to date. The up-to-date methods they kept as trade secrets. And yet that laboratory is publishing the results of scientific research continually!

No doubt many of us have had the unpleasant experience of telling a fellow scientist about some unpublished results, only to find a little later that he has appropriated our ideas and has published them ahead of us. This does not happen often, and would be even less if we as teachers would mention the evil to beginners in research. It usually occurs in the case of the younger element only, so that it is not a very serious drawback to cooperation.

Regarding the borrowing of apparatus, it may be said that borrowing a thing we can not afford to buy is a procedure which might prove embarrassing. When a lack of money is not the motive in borrowing, but rather a desire to use something only for a short time, then it may prove of great value. In any case, it would seem more advisable to use apparatus without removal to another place, as one would thus have less danger of accident, as well as the help of some one possibly better versed in its use.

Turning now to the advantages of cooperation, we find there are many. First and foremost, it has been definitely proven by the success of the large industrial research laboratories that scientific progress is much more rapid when many workers are busy under the direction of a competent head, all working toward the same goal. Every man's time thus counts for the most, as he is only doing what he understands best, turning problems out of his field over to his fellow workers. Right here is where the greatest difficulty arises in the case of academic men, as here there is no research head, the very system demanding absolute academic freedom. Any cooperation among university men must be absolutely spontaneous, if it is to succeed. We can not tell Mr. A to cooperate with Mr. B, but we can educate all scientists to the benefits to be gained, and thus increase the probability of spontaneous cooperation.

Some years ago while attending a national convention, I recall two scientists getting into a very heated argument while discussing the results of a paper which was under consideration. After the battle of words assumed alarming proportions, a peace-maker rose and suggested that if these two gentlemen would only go to one or the other laboratory and try out their ideas together, they would be able to come to an agreement. Thereupon the younger of the two men rose and said, "We used to be in the same laboratory and could not agree, so that is impossible."

This was, of course, the unusual case. In fact some of the greatest benefits have come from just this sort of cooperation. When two scientists are at variance as far as experimental results there is no better solution than actually packing up and going to work under the same conditions as the other man has worked. It usually develops that both are right and that both could make better headway by a continual exchange of ideas. Moreover, in place of a rather strained feeling, they will have substituted mutual respect.

A summary of events leading up to a recent scientific expedition may serve to bring out some of the results which may be looked for in truly cooperative work. There was at one time a theory that flowers were beautifully colored in order to attract insects, with the ultimate idea of cross-pollenization. This was a fine theory which would have satisfied us to-day, had it not been for the fact that some one came along and proved, to the satisfaction of all concerned, that insects were color blind. Not long ago it occurred to a biologist, who knew of the existence of light waves beyond those visible to the human eye, that possibly it was due to our own egotism that we called the insect color blind. Might it not be that insects have a range of vision in the ultra-violet, just as we have in the visible spectrum? Might not two flowers, one red and one blue, both give out the same group of wave lengths in the ultra-violet, and thus be identical in color to an insect seeing only the ultra-violet? Moreover, what is to prevent two different kinds of red flowers from giving out two entirely different sets of wave-lengths in the ultra-violet, and thus appearing to have entirely different colors to an insect? Thus a given type of insect might in reality only be visiting flowers of the same color as far as it was concerned, while to us it appeared to be visiting flowers of all colors.

In order to test out his ideas, the biologist bottled up some flies and took them to his friend the physicist. The flies were placed in a quartz tube so as to permit the ultra-violet rays to enter, and the tube placed end on near a source of ultra-violet light. Light filters were used so that only rays invisible to the human eye entered the tube. In the words of the biologist, the flies went towards the source of ultra-violet light like Quakers to a camp meeting.

Having proved that at least one kind of insect sees light that we do not see, it remained to study the ultra-violet radiations of flowers in their native habitat, and to get positive information concerning what flowers a given insect visits during the course of an hour.

An expedition was organized to the Rocky Mountains and the University of Colorado was made the seat of operations. As a rapid means of learning where an insect had been, it was decided that the pollen on the legs would be a good index. Investigation disclosed that no microscopic study of pollen had ever been attempted, so one research worker was assigned this task. A very excellent piece of work was the result, so that it is no longer necessary to follow an insect over a Rocky Mountain landscape in order to know where it has been. The ultra-violet spectrum of flowers in their natural positions was photographed, and although no very striking results were achieved, yet it was perfectly evident that flowers do have their characteristic ultra-violet radiations.

Unfortunately, the work was dropped at this point, at least temporarily, but the ramifications of the subject would here as in all other work have been endless had it been continued. One subject which would have come in for early consideration would have been the question of odor and the sense of smell. Its study would have required the combined efforts of physicists, biologists, chemists and psychologists.

As has been mentioned before, there is frequently a false concept of the relative importance of one or another science. Nothing could do more to dispel such notions than rubbing elbows with fellow scientists while attempting jointly to work out a given problem. Nothing could do more to develop a friendly feeling and a spirit of helpfulness than to learn that each science is straining every nerve in order to place it in possession of more facts and more fundamental truths.

Regarding cooperation between university workers and the industry, it may be stated that the industrialist on the one hand has often felt that the academic worker was not interested in his problems, and was not of a practical turn of mind. This is in fact frequently justified, but could at times be easily remedied. Any scientist who will but take the time to spend an hour or two talking with an industrialist will shortly find that he is very deeply interested. The interest will be real, because he will see that the problems are his problems, and that he could offer many valuable suggestions, and be of real service to the world, without undue effort on his part. He will see a possibility of increasing his income as well as increasing the esteem in which he is held by the community. The industrialist on the other hand will learn that he must actually approach the scientist with his problems and thus lead him on.

One result which would thus be at least partly achieved would be that the industries would learn to know that what academic workers are doing will, in the long run, be of financial benefit to them. They will learn to realize that although X-rays and the rare gases of the atmosphere never netted the discoverers anything, yet they have helped increase the dividends of more than one industrial corporation. It might be hoped that as a result the industries would be more liberal in their gifts and thus more actively subsidize research.

The layman, seeing the university worker helping the industry, would no longer look upon him as a man who only loved to "play" in his laboratory. This would do much to increase confidence in our schools and lessen opposition of the people to the money spent by our state institutions of higher learning.

In short, if science is to advance more rapidly than before, we must learn to advertise our wares in our home communities as well as before our scientific fellow workers. Such books as "Creative Chemistry" have done wonders in this regard, and Science Service is carrying the work on in an admirable way, but we must all do our share to help.

I often tell my classes that mathematics is possibly the science nearest to being self-contained. The mathematician often fails to realize that his science was created and developed by astronomers and physicists. If a physicist knows mathematics, he can regard himself as having covered his field. He must, however, realize that his science has been greatly enriched by the chemist, who centuries ago wanted to know more about the atom. Thus the chemist must know physics and mathematics before he is complete.

The geologist should know all these subjects in addition to his own, but the task is too great. The same is true with the science of medicine. Just as the physicist and chemist appreciate that they must know the underlying sciences, so also the mathematician, physicist and chemist should realize that they should reach out and help those struggling in the more complex fields such as geology and medicine. The professor of mathematics or physics should not only have his students solve problems, but should also be able to give them an intelligent interpretation of the physical or chemical problem which is under discussion. Cooperation between scientists will not only make this a pleasant task, but will also serve to make the teacher more inspiring to his students. The task will no longer be one of mere form, but there will be a definite object in view.

The sum total of scientific knowledge is so great to-day that no one person can hope to know well more than a small portion of any science. Fifty years ago it was still possible for a man in his lifetime to master several sciences and to make noteworthy contributions to each, but to-day men of that nature are very few. Since all science is interrelated, it is not possible for any one problem to be satisfactorily solved by one man alone. Obviously the greatest need lies in the direction of cooperation between men of allied sciences, such as between chemistry and medicine, between physics and chemistry, chemistry and geology, etc.

There is also need for a better understanding between the industries on the one hand and the pure academic sciences on the other. We in the universities sometimes feel that our chief duty is to furnish men who may go into the employ of corporations and solve their problems for them. However that may be, we must not forget that there is still another mission which we have to fulfil. That mission consists in discovering and making available the raw materials with which the industry works. By this is meant that before we can have a factory making X-ray tubes, we must have had Professor Roentgen working for very low wages in a university laboratory. Before a large chemical plant produced radium, we had Mme. Curie working under similar conditions. Before we could enjoy our modern tungsten lamp, we had to discover, isolate and learn the properties of the metal tungsten. This kind of work has in the past and is still largely being carried on in university research laboratories during the spare moments of professors who are usually accused of not having a practical turn of mind. These same professors would very often be of material service to the industry, if some way could be devised to bring them together. After once having established this friendly relation, the question of the industries helping to finance pure research will take care of itself. In some cases it will take the form of research fellowships, in others that of the endowment of one or another teaching or research professorship. Now it might be a gift of a building and again that of a piece of apparatus which the university could not afford to buy.

Progress to-day is very rapid, but we must not forget that we owe much to those who carefully laid the foundations without thought of reward. One discovery follows another so rapidly that it is hard to keep abreast of the times. Hardly has the radio become commonplace when we learn that accurate photographs are being transmitted by wire. These advances represent the result of cooperative effort, and anything we can do to encourage cooperation will help make progress in the future more rapid than in the past.

FRANK E. E. GERMANN

CORNELL UNIVERSITY

## ERIC KNIGHT JORDAN

### 1903–1926

ERIC KNIGHT JORDAN, the son of David Starr Jordan and Jessie Knight Jordan, was killed on March 10, 1926, by the overturning of an automobile. He was on his way to a geological survey of the Santa Maria region of Lower California.

In Eric Jordan, a great scientific name gave fair promise of receiving new luster. He was hardly more than a boy when he died, for he had been born in San Francisco on September 27, 1903. But he had already achieved distinction in his chosen field. Before entering the university he had made a considerable collection of mollusks of Lower California and of various shores of Europe, while in a secondary school he had prepared a manual of the mollusks of Lower California. This book, which was never published, contained considerable original work, especially on the Chitons and on the minute snails called Odostomia. His studies on the molluscan fauna of Trinidad Head, Calif., were written at the age of fifteen, and published by the U. S. National Museum.

He was graduated from Stanford University in 1923, with geology as his major subject and zoology as a minor. In 1924, under the auspices of Cornell University, he made a large collection of the fishes from Hawaii. Under the direction of the California Academy of Sciences, he later took part in a geological and biological survey of the Off Shore Islands of Mexico, and also in a survey of the middle portion of Lower California. The reports on these last two expeditions are still unpublished.

His chief publications were: "The Mollusks, Living and Fossil, of Lower California, and Their Testimony as to Climatic Conditions in the Miocene Age"; "A Catalogue of the Fishes of Hawaii, with Account of New Species" (in collaboration with D. S. Jordan); "A Review of the Fishes of Hawaii," based on his own collection in 1924. At the time of his death he was a graduate student in geology and assistant curator in the same subject in the California Academy of Sciences.

He was in the perfect bloom of his young manhood; lithe, tall, vigorous, a lover of the High Sierras. A clear-headed and persistent worker, he was also a born executive and a master of English. His love for biological studies approached genius, but there was none of the abnormal or repellant traits of the "prodigy" about him; his personality remained sweet and winsome. He was married but one month before his death to one of his classmates, a gifted and lovable young woman, Elizabeth Roper Jordan. The grief of his bride and of his parents is too sacred for the intrusion of public sympathy. But the scientific world realizes that heredity and early training under an incomparable master had given Eric Jordan opportunities which were perhaps unique. It is a priceless instrument that has been broken. Laboremus!

ALBERT GUERARD

## SCIENTIFIC EVENTS

### MEETING OF THE INTERNATIONAL ELECTROTECHNICAL COMMISSION

LEADING scientific men and engineers of America and Europe will attend a ten-day meeting of the International Electrotechnical Commission, which will be held in the Engineering Societies Building, New York, beginning April 13.

This meeting will be the first to be held in the United States by the commission, which functions through national committees representing the technical societies and governments of a score of nations.

It is expected that delegates will be sent by every country represented on the commission. The preliminary and incomplete list of delegates includes the following:

*Belgium.*—Frans Dupont and M. E. Uytborck.

*France.*—J. J. Frick and M. E. Roth.

*Germany.*—P. Schirp, Dr. Rudenberg, P. Strecker, Dr. Fleischmann, M. Kloss and Richard Stern.

*Great Britain.*—Sir Richard Glazebrook, Sir Archibald Denny, L. B. Atkinson, W. W. Lackie, L. St. L. Penched, Col. F. T. Purves, C. P. Sparks, Sir George Sutton, W. B.