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THE AMERICAN SOCIETY OF NATURALISTS
COOPERATION IN SCIENCE[1]

As investigators in science a great burden of responsibility rests on us. What our sciences shall be in the middle of the century depends on how we build at the opening of the century. History shows this to be so. In the last century embryology attained its importance because of the activity of its founders, including Wolff, von Baer, Kowalevsky and Balfour, while modern cytology received its impetus from the labors of such men as Fol, Flemming, Hertwig and Mark. As we look to the work of these men, so the future investigators will look back to us with a true and final judgment and determine our place in the development of our subjects. Well were it for us if this decade, this year and this meeting were memorable for an increased devotion to the scientific interests of which we have become the trustees. To advance these interests we should do well to adopt principles which have worked successfully in other fields of activity. In the modern commercial world one of the most important principles is cooperation. Let us consider the development of cooperation in science to learn how it may be advantageously applied further among naturalists.

The ancient Greeks made investigation of nature primarily to illustrate their personal systems of philosophy. This form of investigation, unhappily not yet wholly obsolete, is manifestly incompatible with

[1] Annual address of president read before American Society of Naturalists, December 29, 1906.

cooperation, which thrives better the more objective the method employed. Although Aristotle had a love of discovery, he and his followers were so scattered that at this period there was little opportunity for cooperation. With the development of astronomy and mathematics in the middle ages the number of centers of research multiplied and we find evidence of jealous rivalry between astronomers: for it was customary to announce discoveries in cipher, pending their confirmation or further study. If, in the meantime, the discovery was announced by another, the first published the key to his cipher and maintained his priority of discovery. This cipher is, I presume, the ancestor of the modern preliminary notice.

In more recent time astronomy, the best organized of the sciences, has led the way in cooperation. She has been almost forced to do so by the expensiveness of the equipment of an observatory and by the magnitude of the tasks before her. Consider, for example, the work of mapping the heavens, a work requisite for the eventual determination of the movements of the stars, but of such proportions, however, that it could not be accomplished by one observatory alone, with the desirable thoroughness, inside of one or two centuries. In the year 1887 an international congress of astronomers was called at Paris to consider cooperation in making a star-atlas and the adaptation of photography to the work. Eighteen observatories entered into the plan. The position of thousands of stars had to be determined directly by the meridian circle. It was necessary, also, to take over 44,000 photographs of parts of the heavens; a work involving great technical refinements. The star-atlas is now nearing completion, sixteen volumes out of the twenty that are to appear having been already issued. This undertaking stands as the greatest example of cooperation in the history of science.

Other cooperative enterprises have been started by astronomers, such as making latitude determinations, and advancing solar investigations. Thus, last year, the International Union for Cooperation in Solar Research voted the following principles which, with certain changes, might well be adopted in other sciences:

1. Cooperation is desirable in the various branches of solar research [as enumerated]. 2. When an institution has collected and coordinated results from various sources, members of the union shall be requested to place their observations at the disposal of the said institution. 3. In the case of investigations which have not yet been thus collected and coordinated, special committees specially nominated by the union shall be charged with the work of preparing and carrying out the needful cooperation. 4. It is proposed forthwith to organize such cooperation in two branches of research: (*a*) the study of the spectra of sun-spots; (*b*) the study of the records, by means of the H and K light, of the phenomena of the solar atmosphere. 5. The committee lays special stress upon the fact that, notwithstanding the obvious utility of cooperation in certain cases, individual initiative is the chief factor in a very large number. It is as much the duty of the union to encourage original researches as to promote cooperation.

The foregoing account shows that astronomers have acquired the excellent habit of combining forces to carry through a large project.

In certain other sciences, also, cooperation has long been practised. Thus in biology the collections of expeditions are usually worked over by many investigators who publish together in one series. The publication of the results of the *Challenger* expedition is one of the greatest examples of such cooperative work. These fifty thick quarto volumes, containing altogether 30,000 pages of letter press and over 3,000 plates, have been the work of scores of hands and the distribution of the labor was international. What is true of the *Challenger* expedition is true also of a score of other large expeditions; indeed it is the

custom of systematic workers in different groups of animals and plants to cooperate without pay with any naturalist who may send them species for identification.

The international congresses which in the past few years have multiplied so as now to include nearly all of the sciences have stimulated cooperative undertakings. The International Association of Academies has organized commissions in the geodetic and seismological survey of the earth and on terrestrial magnetism. In electricity there are international committees on electromagnetic units and standardization. At a recent international meteorological congress cooperative work was initiated for the construction of a cloud atlas, also for studies on solar radiation, and no aeronautics. The exchange between nations by telegraph of current meteorologic observations is being constantly extended. The chemists have an international committee on atomic weights. The botanists and the zoologists have each an active international committee on nomenclature. The International Congress of Experimental Psychology has commissioned individuals to make comprehensive reports on special subjects. All the foregoing examples of the international congresses (of which others might be cited) involve much cooperation between men of science, who not only travel far to attend them but also work together in committees to further the investigations of largest scope.

The national societies involve, likewise, even though less strikingly, the spirit of cooperation. At this season of the year we prepare our papers with much pains, we leave our Christmas firesides and we travel great distances, spending freely of time and money, to advance these meetings that we believe to be for the common good. We meet together both formally and informally and we exchange very freely our ideas and discoveries. These meetings illustrate in the most practical way the spirit of goodwill, reciprocity and cooperation of this holiday season. The only regret that we hear, the only limitation to satisfaction that we feel, is that the programs are too full to permit of sufficient discussion and that several programs of common interest are running simultaneously. This year, in the biological sciences at least, a distinct improvement has been made, in that the sections of the association have cooperated fully with the special societies by arranging joint programs. A further example of cooperation this year is the joint session of the zoologists and botanists for topics in heredity and plant and animal breeding, and there have been in recent years a few individual cases of participation by members of one society in the proceedings of the other. Such cooperation between biologists is so helpful that it leads us to inquire whether it ought not to be better organized.

Let us consider for a moment the relations that have existed between the botanists and zoologists. The early systematists, such as Ray and Linnæus, included both plants and animals in their studies. Later, as species multiplied, the systematists of the two realms divided sharply. To-day we see the division carried still further on the basis of materials studied; so that we now have entomologists—lepidopterologists, coleopterologists, etc., indeed—and conchologists, ichthyologists, helminthologists, and so on. These divisions are excusable only in systematic work. One can not but regret to see scientific men segregating themselves on the basis of materials studied. In other sciences it is not so. To be sure, the chemistry of organic compounds assumed such importance some years ago that university chairs in that subject were organized and even societies founded; but I think it is true that no further segregation on the basis of material will take place in chem-

istry and that even now the group of 'organic chemists' is dying out. The newer problems of physical chemistry know not the old boundaries. The sole unit of classification of workers is the problem or subject.

So might it be in biology. The whole realm of living matter is one and indivisible. The fundamental laws of action of protoplasm, no matter how diverse its form, are everywhere the same. A comparative study of these laws on all sorts of material is necessary in order that the primary and essential may be separated from the secondary and non-essential. For example, the cell-wall was long regarded by botanists as the essential part of the cell, until studies on animal tissues showed that it had a secondary significance and that nucleus and cytoplasm are of more general importance. No student of plant physiology can fail to recognize how much modern concepts in that science have been influenced by studies on animals and even on man, while, on the other hand, the young science of general physiology of animals has received its true direction and impetus from studies on plants. In still other subjects we must recognize the identity of phenomena in the two kingdoms—little longer to be kingdoms, I trust, but soon united states. In both, processes of cell-division are essentially alike. Maturation, fertilization and cleavage of the egg differ only in illuminating secondary details; the general embryological principles are the same; the form is similarly restored after injury. Not less strikingly alike are the laws of fluctuating variability—since the delicate test of statistics shows no essential difference in the variation surfaces of plants and animals. As for mutation and inheritance, the warnings of some zoologists that the recent discoveries in plants should not be hastily applied to animals have fallen on deaf ears, for the fact is startlingly manifest that in all organisms these functions are identical. Even as producers of obscure diseases, plants can claim no distinction from animals. Within the last few years the number of disease-producing Protista that have animal affinities has increased by leaps and bounds until the very name of bacteriology threatens to become extinct. Pathogenic micro-organisms, without regard to their situation in the 'realms,' now constitute the material of the former bacteriologist. From all sides come forceful facts, beating down the artificial barrier that systematists and anatomists have erected athwart the field of biology.

This barrier must go. Already there are comparative cytologists, students of growth and regeneration, biometricians, thermatologists and protistologists who have destroyed much of it. General physiologies are written that disregard the old boundaries. Societies are being founded which, like the American Breeders' Association and the Deutsches Gesellschaft für Züchtungskunde, ignore the conventional dividing lines. Botanists and zoologists have gladly cooperated in these undertakings, having forgotten all minor differences in the essential fact of being biologists. The International Conference of Plant Breeders, held last summer, had for its president a noted zoologist.

Colleagues, there are many biological matters which call for immediate cooperation. There is the matter of the regulation of changes in the nomenclature of our some half million of species. This nomenclature is a cooperative work of the first magnitude, but is there any other instance of so large a cooperative undertaking with so little central control? This nomenclature is made up of the decisions of an army of men and women of the most varied learning, judgment and experience. To qualify for the work of adding to or altering this nomenclature no notice is given, no exam-

ination as to fitness is passed, no license or certificate is obtained. Nowhere is a statement as to minimum training necessary. A decision once rendered in print is thereafter to be quoted forever. The decision may, indeed, be reviewed and set aside, but the reviewing judge may be inferior in age and experience to the reviewed. Despite the fact that many of the judges are men of great learning and conservatism, the result of this uncontrolled cooperation has been and is infinite confusion. Only a small proportion of us here have anything to do in making biological systematic nomenclature, but all of us have to use it. And we are tired of the reproaches of our nomenclatorial brethren that, in referring to some species, we have overlooked a (usually *his*) recent change of a name. As biologists, we are to blame not for having overlooked a change of name, but for permitting the names of species to be changed by the whim of any one. As biologists, we are responsible for systematic nomenclature. It will not suffice to disdain the species monger. We are responsible for his existence. We may scoff at the condition of our nomenclature, but we can not forget that we permit it to be what it is and that here in congress assembled we could to-day take steps toward putting it on a rational basis. A commission should be appointed composed of representatives of both sides of the house, which should work with other committees already in existence, and which should report on the best method of controlling, here in America, the naming of species and the changing of established specific and generic names. It seems to me clear that such a commission would seek in vain for a universal natural basis of species. Arbitrary rules must be made and enforced by outlawing new names not in accord with them. It is time to stop the changes and adjustments of names to meet different ideals. We have a nomenclature which, in most groups, accords closely enough with nature for our purpose. Let us henceforth arbitrarily protect such a nomenclature. Some steps have been taken in this direction. As indicated above, the international congresses of zoology and botany have established certain very general suggestions as to nomenclature. American ornithologists have gone further and laid down the rules under which new species shall be created. They have even published a list of specific names which are to be recognized. The international congress of botanists last year approved a series of *rules* and *recommendations*, enacting that 'a name contrary to a *rule* can not be kept up.' It passed a list of generic names, which, from long-established usage, are to be retained, though on the principle of priority they should be rejected. This action is important, in my opinion, because it affords a precedent for establishing generic names by vote of a congress. While an American *biological* commission on nomenclature is desirable, in order to begin the immediate consideration of reforms in our methods of naming species and to gain experience, we should work toward a permanent international committee on *biological* nomenclature.

Important though nomenclature is, it can not command the same interest as research. There are large undertakings in the field of general biology that require a more systematic cooperation than yet exists. The greatest of these is the experimental study of the factors of evolution—experimental evolution, in brief. The station established by the Carnegie Institution of Washington has done something to enter into cooperative relations with workers in this field both in America and abroad. These associated workers would doubtless be very glad to serve as a committee to report to a society of biologists.

The matter of the significance and con-

trol of sexual dimorphism is one of such moment that it might well be assigned to a special commission including both cytologists and experimental breeders. The subject of the physiology of ontogenesis, including experimental embryology, form regulation, and experimental morphology, is one in which American zoologists and botanists have made their country famous, yet the exploration of the subject has only been begun. The investigators should all come together from time to time to consider new lines of advance. As further examples of investigations needing cooperation I may mention the determination of biogeographic centers and the routes and means of dispersal; the basal instincts and reactions of organisms—but these will suffice as examples of subjects of common interest to all the biological societies; zoologists, botanists, bacteriologists, anatomists, physiologists, thermatologists and psychologists. Such subjects may not be left to the different societies separately. It is because none of the existing special societies can appropriately assume charge of these general biological topics that their interests have not been as much advanced as they ought to have been. Some attempt has been made to meet the need by occasionally arranging joint meetings between botanists and zoologists, and in the last two discussions of the naturalists a symposium has been held on some general biological topic. But it is clear that there should be a special society for the cultivation of these subjects.

The American Society of Naturalists was established in 1883 as an association of professional naturalists. The original call was signed by fourteen persons, all but one biologists. Although many geologists joined the society later, most of them subsequently withdrew to concentrate their interests on the Geological Society of America. Many other special societies have sprung from the loins of the Naturalists, but, for the most part, the individual biologists have clung loyally to the parent society. It has been suggested recently that the Society of Naturalists is an anachronism; that its interests are too diffuse; that we must concentrate now on the special societies; that, now her children are grown, the mother should die. With this view I do not agree. I have tried to show that there is not now less need but more of a synthesizing biological society with the following aims: To arrange for an annual discussion of some burning biological topic; to arrange with the special societies one session for technical papers of interest to both zoologists and botanists as well as biologists of other societies; to arrange, through the appointment of commissions from time to time, for cooperation in the control of biological nomenclature and for the cooperative study of certain large topics. Such commissions should be composed of those specially investigating those topics and should do what they can to encourage independent work also in these lines. They should report briefly each year to the society.

Next year the Society of Naturalists will celebrate the twenty-fifth anniversary of its birth. Can it do so more fittingly than by arranging a series of brief reviews of the progress in the past quarter of a century of the larger cooperative undertakings in biology, with suggestions as to their better organization?

C. B. Davenport

THE BIOLOGICAL SIGNIFICANCE AND CONTROL OF SEX[1]

THE NATURE AND SIGNIFICANCE OF SEXUAL DIFFERENTIATION IN PLANTS

You will pardon me if in discussing the subject which has been assigned I take my

[1] Five addresses given before the American Society of Naturalists at Columbia University, New York, December 28, 1906.