Tularosa Mountains, for, say, one year, under competent instructors and subjected to drill and obedience not alone in the use of arms but of tools and in building some hundreds of thousands of these little structures, the young men would be better off and the Nation wonderfully enriched. There would be recreation and sport of occasionally killing a black tailed deer or a wild turkey or the gray squirrels, which we saw almost every hour of every day while in this region. Our national life would not only be reinforced through a pronounced conservation achievement along material lines, but the spirit of true national defense would have a new birth.

# RESEARCH WITH A HEN[1]

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THE subject of this address was unwittingly suggested by a member of the board of governors of one of the largest universities in the United States. This institution employs upwards of two hundred graduate students as assistants in research and in teaching, but when the board was requested a few years ago to appoint a research assistant in the Department of Poultry Husbandry, it was confronted with a situation quite unprecedented in all the years of the university's existence. It was not surprising, therefore, that one member of that body should have expressed his doubt about the desirability of the proposed new appointment, but it was surprising that he should do so by asking the very pointed question, "What research can you do with a hen?"

What research can you do with a hen? Among the members of this society there are over a hundred who could answer this question by quoting investigations now under way in the various universities and experiment stations which they represent, and concerned with the nutrition, genetics, physiology, embryology, pathology, parasitology or psychology of the fowl. These experiments are planned in nearly every case to discover new facts and to add to our store of knowledge. It is because such investigations have been carried on for many years that we now have a sufficiently great accumulation of facts to justify the designation of this branch of knowledge as poultry science.

To discuss research intelligently we must have an understanding of what the word implies, but, in attempting to define it, no one realizes better than I the difficulty of giving any arbitrary and fully satisfactory definition. As every director of an experiment station knows, there are investigations of divers kinds, not all of which are entitled to be designated as research. Some are merely *re*-search, but, in so far as they improve upon previous methods and by so doing establish new facts or provide more accurate interpretations, such investigations may fairly be classified as research. This can hardly be said, however, for the all-too-common repetition of experiments in which the results have been so conclusive that additional substantiation is entirely unnecessary. Nor can we classify as research those investigations in which sources of error and of environmental modification of results have been so ill-controlled that no definite answer to the original problem is provided by the experiment. Fortunately such experiments are becoming fewer.

The majority of our experiments, however, are set up to determine new facts about the hen and about other domesticated birds. Except for studies of costs of production, which are largely economical rather than biological in nature, our investigations are concerned with the hen's nutritional requirements, her physiology, her genes and the characters they produce, her embryonic and postnatal growth, the parasites that beset her, the bacteria that invade her and, withal, the mental processes that are responsible for her often inexplicable peculiarities of behavior. In pursuing these researches we usually apply already well-known principles of nutrition, physiology, genetics, embryology, parasitology, bacteriology and animal psychology. We are not concerned primarily with extending the boundaries of these fields of science, but rather with utilizing them to give us more information about the fowl. However, if an investigation adds one small fact to the already large amount of knowledge about the hen, that investigation is undoubtedly research so far as poultry science is concerned. It may also be called research in nutrition, genetics or any of the other sciences, if it extends to a new species the application of a principle not yet known to have universal application.

But there is still another kind of research with a hen, a kind which has not been adequately appreciated even by members of this association, and certainly not by the gentleman who asked, "What research can you do with a hen?" I refer to those investigations in which the hen has been used, not for the application of existing principles, but for the discovery of entirely new concepts in biological science.

[1] Address of the president at the twenty-fifth annual meeting of the Poultry Science Association, East Lansing, Michigan, August 2 to 5, 1933.

To begin with, our whole knowledge of early embryology of vertebrates rests largely upon the great body of facts which has been accumulated about the development of the chick. As early as the fifth century B. C., Hippocrates, the father of medicine, was advising his students to verify his teachings of human embryology by daily examination of incubating eggs from the second day to hatching and assuring them that therein "you will find everything as I say, in so far as a bird can resemble a man." Twenty-three hundred years later I send many dozens of eggs each year to the modern disciples of Hippocrates at our university in order that they may do just what he directed.

A century after Hippocrates, Aristotle wrote a description of the development of the chick embryo which was so remarkably accurate that little improvement was made upon it until the work of Fabricius ab Aquapendente early in the seventeenth century. Nevertheless, up to the time of William Harvey (1578–1657) there was no clear conception of where or from what materials the embryo of either birds or mammals began its development. It remained for that scientist to show that in the hen's egg the little light spot on the yolk, which he called the cicatrula, and which we call the germinal disk, or blastoderm, was the original center of growth. It was not a far cry from this discovery to his all-important doctrine of *ex ovo omnia*—"all things come from eggs." It is interesting to recall that Harvey, whose demonstration of the circulation of the blood marked perhaps the greatest single advance that physiology has ever known, was a keen student of the embryology of the chick, and that his "Anatomical Exercitations on the Generation of Animals" was based almost entirely on his observations of chick embryos.

A little later, under the microscopes of Malpighi, the chick afforded to man his first view of the neural groove, the somites and the optic vesicles, characteristics of all vertebrates at early stages of their development. Malpighi's studies, published in 1672, may be said to have established the chick as the animal *par excellence* for both microscopical and macroscopical studies in embryology, and, in succeeding years, with its aid, Wolff, von Baer, Balfour and others laid the foundations of our present detailed knowledge of embryonic development A glance through any current journal of zoology or anatomy will show that the chick's usefulness in this field is by no means ended.

If the chick has been of service in revealing the processes of normal development, it has been of equal value in the experimental study of teratology or abnormal development. The difficulties of experimental manipulation of mammalian embryos are obvious. On the other hand, the chick embryo is ideal for this purpose, because, in the words of Dareste, "the fertilized ovum is endowed by fertilization with the capacity for development, it is separated completely from the maternal organism; it results therefrom that the egg which contains it can be submitted to all the influences which we believe capable of modifying its development." It is not surprising, therefore, that the chick embryo should have been utilized by Geoffroy Saint-Hilaire, one of the founders of teratology, or that Dareste should have devoted practically his whole life to the experimental study of abnormal development in the same species. To-day the more recent science of experimental embryology, the "Entwicklungsmechanik" of Roux, counts the chick embryo among its most useful subjects for research.

Man's knowledge of the physiology of reproduction was greatly clarified by two important advances at the close of the seventeenth century. One of these was the discovery of mammalian ova by De Graaf in 1672; the other occurred two years later, when a Dutch medical student, Ham, saw for the first time the myriads of minute animalculae which we now know as spermatozoa. Professor Punnett quotes Fridericus Shrader as authority for the statement that these were first detected by Ham in the semen of a male fowl. This seems not unlikely, for in 1677 in one of his numerous letters to the Royal Society of London, Leeuwenhoek, to whom Ham had revealed his discovery, stated that he had been able to find in the semen of a cock a "huge number of little snakes or eels," which were not to be found in the material from hens. Ham's discovery was the result of a decidedly valuable research in which the fowl proved to be a most useful animal.

The contributions of the fowl to science thus far mentioned were mostly made before the eighteenth century. To show you that the hen is still in the rank as a laboratory animal, I should like to describe a few more recent important advances in which she has played a part.

It is doubtful if the world has seen any more dramatic demonstration of a scientific fact than that given by Pasteur in 1882 at the farm of Pouilly le Fort, near Melun in France. The great scientist had offered to convince a skeptical world that he could make animals resistant to anthrax, a disease which up to that time was rightly considered as one of the worst scourges afflicting domestic animals. Twenty-five sheep were inoculated twice with attenuated organisms of the kind causing anthrax, and twenty-five others were set aside as controls. Subsequently, all sheep in both lots were given a virulent dose of the organism. Within five days every control sheep was dead, but of the twenty-five that had been inoculated all were in perfect health except one that died from conditions associated with pregnancy. The potentialities of vaccination were established.

Let us remember, however, that this dramatic and convincing experiment would not have been possible if Pasteur had not first discovered that the deadly organisms could be attenuated, or weakened, until they were capable of causing only a mild infection to which the body could speedily build up a resistance. This fundamental discovery was made not with *Bacillus anthracis,* but with the organism causing fowl cholera. It was the discovery that aged cultures of this bacterium produced only mild and temporary symptoms of the disease that led Pasteur to the successful use of attenuated organisms as a means of building up resistance to anthrax and, later, to other diseases. Research with a hen has not been barren in the field of bacteriology.

Let us consider endocrinology, probably of all the biological sciences the field of greatest activity at the present time. It is well known that the secondary sex characters of the fowl are easily modified by subjecting them to the influence of hormones of the male or female gonads, or by complete gonadectomy. Moreover, the feather follicle can be used to excellent advantage as an indicator of thyroxine. For these reasons the fowl has been selected as a favorable subject for the study of sex and secondary sex characters by research laboratories in Chicago, Edinburgh, Strasbourg and Moscow, as well as by numerous individual workers. Apart from all the present activities, however, let us keep in mind that the first actual demonstration that there was any such thing as an endocrine secretion was made by Berthold in 1849, when his transplantation of testes of the fowl was followed by typical male-like growth of the comb in the recipients. It is true that Berthold, like many another investigator, did not fully appreciate the significance of his discovery at the time, but that does not vitiate the importance of his research as the first step in the now tremendously complicated field of endocrinology.

The Dutch physician, Eijkman, is justly famous for his experiments in 1897 in the etiology of beriberi. It should be remembered that these investigations were prompted by his discovery that fowls fed the garbage from the hospital of the Javanese prison, at which he was medical officer, contracted a paralysis very similar to that afflicting his patients. This led him to conduct experiments in which some fowls and pigeons received rice with the outer layer left upon it, while others were given only polished rice. When the latter group contracted the degeneration of peripheral nerves, which Eijkman designated as *polyneuritis gallinarum,* it was the first time in history that a disease of dietary origin had been experimentally produced. It is little wonder that Eijkman's findings should be hailed by Dr A. V. McCollum as "the most remarkable observation in the history of beri-beri, and the one which inaugurated the modern era of investigations in the field of nutrition." Obviously, research with a hen has been decidedly worth while in that branch of science.

In the field of genetics, the fowl has been so extensively studied that more is known about its inheritance than that of any other domestic animal. This is not surprising, partly because of its more rapid rate of reproduction, but also because the domestic fowl was the first species to bear witness that Mendel's laws apply to the animal kingdom.

When William Bateson presented to the Evolution Committee of the Royal Society his initial report on "experimental studies in the physiology of heredity," covering extensive researches with four species of plants and with poultry, that document included sufficient data to show conclusively that rose comb, pea comb and the dominant white of White Leghorns were simple dominant characters, segregating in a 3:1 ratio in the $F_2$ generation and in a 1:1 ratio in back-crosses. It is important to remember that this report was presented on December 17, 1901, and that the experiments were begun in 1898. It is difficult to escape the conviction that, if Mendel's laws had not been rediscovered in 1900 by De Vries, Correns and von Tschermak, they would have been worked out independently by William Bateson. It has well been said that, were it not for Mendel, Bateson might be sleeping in Westminster Abbey.

From this auspicious beginning the fowl has continued to provide valuable material to the geneticist, including one of the first cases known of sex linkage, the first experimental demonstration in domestic animals of the possibilities of reducing losses from disease by breeding resistant strains, unrivaled evidence of the value of the progeny test, information about the phenomenon of crossing-over in females having only one sex-chromosome, to say nothing of the variety of morphological characters, which, I venture to predict, will some day be utilized to find out how the gene gives rise to the character, a field of genetics as yet practically unexplored.

More of these examples might be given, but I have cited enough to show that the hen has a right to stalk with pride through almost any biological laboratory, whatever its particular fields of activity may be. Nor has she shown the narrow specialization of Drosophila, of the albino rat, or the guinea-pig, whose spheres of usefulness are largely confined to the researches of the geneticist, the nutrition specialist or the bacteriologist, respectively. She is, withal, a lass of many parts.

As poultrymen we respect the hen as being of all domestic animals the most efficient converter of raw materials into edible food stuffs. We respect her as one of the most profitable sources of farm revenue, the mainstay of many a farm home where crops have not yielded the promise of spring. As biologists, let us also respect her as one to whom science owes no inconsiderable debt of gratitude. It is fitting that we should draw on all the resources of science to keep her in a state of maximum efficiency, to prolong her useful life, to prevent the ills to which she is subject and to raise her progeny with a minimum of loss. By so doing we make some slight return for the contributions to knowledge which have resulted from "research with a hen."

# SCIENTIFIC EVENTS

## THE ALGERNON FIRTH PATHOLOGICAL INSTITUTE AT THE UNIVERSITY OF LEEDS

*The British Medical Journal* reports that the recently opened Algernon Firth Pathological Institute in Leeds will include the university departments of pathology, bacteriology and cancer research, thus coordinating investigation and teaching, as well as facilitating the application of new scientific discoveries to the social and industrial needs of the community. Including its equipment, the provision of the building has cost approximately £50,000. Half this sum was offered by Sir Algernon Firth, at the instigation of Lord Moynihan, on condition that in the new building there should be suitable accommodation for cancer research. Sir Algernon, who opened it, mentioned that he fully realized the continuing value to humanity of a research building under the control and care of so permanent an organization as the University of Leeds. Cancer research might diminish or even terminate with the attainment of success in its objective, but the need for persistence in other investigations to reduce the sum of human unhappiness would still remain. The pro-chancellor, Colonel C. H. Tetley, accepting the definition of the Firth Institute as the keystone of a structure which had been built up gradually, insisted that the achievement had only been rendered possible by the collaboration with the University of the City Council, the General Infirmary and other Leeds hospitals, and the Yorkshire Council for Cancer Research. He hoped that the one remaining unfinished part of the scheme, namely, the furnishing and equipping of the pathological museum, would be accomplished before long by yet another instance of cooperation. Professor Robert Muir, of Glasgow, summing up the outlook of the institute, said that, since it was impossible to vest in one person both clinical knowledge and the faculty of applying scientific methods, the information resulting from these two lines of observation should be fused so far as was possible. The institute would make it one of its obligations to promote the close cooperation of physicians and surgeons with laboratory investigators, involving an interchange of ideas, and would combine routine hospital pathological inquiries, teaching and research. The number of problems capable of being attacked by independent workers was rapidly diminishing. The many problems that remained demanded a combined effort on the part of workers possessing very different scientific qualifications. Cooperation and organization, Professor Muir added, were becoming more and more essential, and there was no disease which could not be more clearly elucidated thus. The determination of the presence of cancer in its earliest stage in any part of the body was a goal which was being keenly approached by workers starting from various points and applying different branches of scientific research. Vast benefits would accrue to the whole community when these coordinated, though very diverse, activities attained their joint objective.

## JUNIOR SCIENCE CLUBS OF THE AMERICAN INSTITUTE

THE American Institute's Junior Science Clubs held three meetings on Saturday morning, November 4, for its seven thousand members, all of whom are under eighteen years of age. The meetings, centering about the general themes of biology, physical science and general science, attempted to make some real contribution to the individual interests of each of the two hundred member clubs.

These three meetings, on different science subjects, are a part of a plan to assist the "young scientists" of the city. The speakers, all of whom are well known in their different fields, agreed to devote the morning to the presentation of phases of science which the junior clubs could, themselves, begin work in. The talks were planned to lift science above the routine of the classroom and to demonstrate to the children its place in their own lives. The chairmen of the divisions, with the speakers and their subjects, follow:

At the College of the City of New York: Junior Science, *chairman,* Mr. Alfred Knight, vice-president of the American Institute, fellow of the Royal Astronomical Society. Speakers: Dr. Raymond L. Ditmars, curator