the solution of the mode of origin of the nerve fiber. When the cell theory was established, neuro-histologists set for themselves the problem of ascertaining the genetic and morphological constitution of the nerve fiber in terms of the cell doctrine. A three-cornered controversy arose which was waged for seventy-five years, now in favor of one party, now in favor of another, but at no time set to rest by unanimity of opinion. The ablest anatomists of Europe, including such men as Schwann, Balfour, Wilhelm His, Ramon y Cajal, Bethe and many others, tried by observations upon the developing embryo to show whether a nerve fiber is a product of many cells or whether it represents a protoplasmic outgrowth of a single cell. With the aid of remarkably fine methods of histological technique and with the most critical powers of observation which these men possessed the problem could not be solved to the complete satisfaction of all parties. In 1905 Herman Braus, a noted German anatomist, used the method of embryonic tissue grafting as a means of solution. This method had been employed previously in experimental problems by Harrison of this country. Although the experiments by Braus were ingeniously carried out, his interpretation of the results was soon after shown by Harrison to be incorrect. Harrison repeated the work of Braus under more critical circumstances and was able to produce powerful evidence foreshadowed in the work of His and Cajal that the nerve fiber is a protoplasmic outgrowth of the embryonic nerve cell. But there were still doubters as there always are. In order to place this discovery beyond the doubt of the opposers, Harrison invented tissue culture or the growth of tissues outside the body. He placed living embryonic nerve cells in clotted lymph on a microscopic slide, sealed the preparation against bacterial invasion and placed his preparation upon the stage of a microscope. There he was not only able to see with the eye the nerve fiber growing out from the cell as a protoplasmic extension, but he was able to measure the rate of growth. This critical experiment has had far-reaching results. It provided the basis for a definite concept of the genetic and structural architecture in the nervous system which has been of immense importance to neurology and the associated sciences, psychology and psychiatry. Furthermore, it was the beginning of a new method in the biological sciences, *viz.*, tissue culture, which is now extensively employed in nearly every research institution which aims to study cellular physiology.

If time were to permit I could cite to you other examples of the important results that have been attained by the critical usage of the experimental method. The importance of this method in the study of problems in endocrinology is a matter which you will hear of first hand from my colleague, Professor Smith, who has done such brilliant work in this field.

Medicine is no doubt headed towards the stage of exact science, and its ultimate success lies not in the treatment of symptoms, but rather upon the cooperative investigation of causation. Every patient is a research subject and every malady a research problem. The intelligent study of cause and effect in diseased organisms must be preceded by a working knowledge of cause and effect in the production of normal or essentially normal organisms. Medicine is thus demanding more and more the cooperative efforts of all scientists who venture to inquire into the matter of causation in the biological world. As a result, departmental barriers are rapidly crumbling save perhaps for the purposes of administration. Consequently, we find bacteriologists working under the roof of surgery, neurologists in obstetrics, physicists in general biology, chemists in anatomy or pathology and so on.

During your first year in medicine much of your time will be consumed in the study of the human body in the more restricted sense, as a background for pathology, medicine and surgery, and you will have little time yourself to indulge in the scientific end of the subject. We hope, however, that the present staff in anatomy will be able to present matters to you with a view-point that will make the subject of anatomy living in spite of your necessary occupation with a dead organism.

Whether you become an anatomist, a bacteriologist, a surgeon or a practitioner of general medicine does not concern us so much as does our desire to give you your morphological training in such a way that you will pass on, not only with a dynamic concept of anatomy, but with an acquaintance and appreciation of the methods in biological investigation which you will later use as necessary instruments in your endeavor to advance the field of medicine.

SYMPATHETIC MAGIC IN MODERN GUISES

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FROM the earliest ascertainable periods of human activity and thought the assumption that a cause in some simple way resembles its effect has been the great obstacle to progress. Of course, the terms, "cause," "effect" and "resemblance" *may* be defined in such a way that the assumption is true, but the

terms are here to be understood in accordance with the popular usages on which the formulation of the assumption is based. In so far as man tries to control the course of nature (an attempt which is always his ultimate goal) this assumption gives rise to what the anthropologists designate as *sympathetic magic*. In order to facilitate the capture of game the savage carries out operations which, in a pictorial way, are like the capture. To facilitate the fruiting of his orchards and fields primitive man performs coitus at times and places which seem to him appropriate. To afflict his enemy the savage makes an image which resembles the enemy, and pierces, burns or otherwise maltreats it.

The early history of medicine is honeycombed with sympathetic magic. Parts of a strong animal make the eater strong. Plants which in leaf, root or fruit resemble human organs are supposed to affect those organs in helpful or harmful way. In more modern times homeopathy was based on the assumption that drugs producing the symptoms of ailments were effective in curing those ailments. Popular superstition to-day includes a multitude of sympathetic magical therapies, from the tying of a red string around the neck to prevent nosebleed to acceptance of the doctrine that believing that one is well makes him well, and that confidence in one's ability bestows the ability.

In anthropology itself the dependence on analogy has exercised disastrous effect. The most striking instance of this kind, of course, has been the assumption that a primitive design or form which resembles or represents (to the anthropologist) some object or situation, represented it for the primitive mind, and was the cause lying behind the production of the object. Artifacts, for example, which in a loose way resemble the sex organs were assumed to have been produced for that purpose, regardless of any actual historical evidence. Anthropology has freed itself largely from this blight, although the tendency of certain schools to assume that cultures resembling certain other cultures must stand in the direct relation of cause and effect is evidence that sympathetic magic is not entirely renounced. The Freudians, however, took over the magic system which the archeologists discarded and made it the basis of their symbolic interpretation.

The Freudians, perhaps, have made more use of analogy than any other modern group. After all, the "repressed desire" (or the "complex" or whatever term is currently fashionable) is a fictitious entity constructed on analogy from the symptoms of the patient, like the wax image of his enemy which the savage constructs, or like the picture of the speared animal which the primitive hunter made to aid his hunting, and the removal of the "repressed desire" is literally an operation in sympathetic magic.

The strength of sympathetic magic doubtless lies in the fact that sometimes the cause does resemble the effect (still following the common usage of the terms). The omnipresent tendency to generalize widely on a few cases, whether these cases are exceptional or not and regardless of the superficiality of the resemblance, continues to be the bane of science as well as the foundation of superstition. The upward progress of science depends very largely on the success with which it excludes analogy from its inferences, however much it may be interested in the analogies themselves.

At the present time the most pernicious form of sympathetic magic, from the point of view of science, is that which afflicts some phases of genetics. The efforts to demonstrate the "transmission of acquired characters" which have so far been made seem to be based altogether on analogy of cause and effect, and in so far as these efforts are really directed towards the ultimate control of heredity they are phases of sympathetic magic.

The question whether or not the environmental forces working upon an animal do or do not affect its progeny is not really involved here. The important point is that those who have attempted to prove the effects of environment genetically have uniformly proceeded to search for the "transmission of acquired characters," that is, for effects which shall resemble the causes. Now it is not impossible that in certain cases effects may resemble causes, but the antecedent probability of such resemblance must, in any given case, be exceedingly small. When working with any given cause, therefore, searching merely for effects which resemble it is a foolish limitation of the quest, which renders the probability of success practically negligible.

Let us take an illustration. It has been believed that if parents engage systematically in intellectual pursuits of certain kinds their activity may affect their progeny. There is nothing foolish in this assumption *per se*. It is, in fact, a hypothesis which may be experimentally useful. But the effects, and the only effects, which have been postulated by the neo-Lamarckians are effects resembling the causes, namely, increased intellectual efficiency of the same kind on the part of the progeny. This is indeed an assumption which has only an infinitesimal probability of accuracy.

To investigate the responses of mice to a dinner-bell through examination of the progeny of the mice or the responses of rats trained in a maze through examination of their progency may be a sensible scientific procedure. But to assume that any par-

ticular characteristic of the animals may be affected by the "training" of their ancestors, and to look for nothing else, seems a sterile procedure. Antecedent to the discovery of specific mechanisms through which specific effects may be "transmitted," a change in the diameter of the vibrissae of the rodents or of the coloration of the skin is just as probable an effect as a change in some detail of behavior. The chances of positive results are (if I may use an analogy merely for illustration) of the order of the chances of discovering a penknife lost in a ten-acre field by making a chart of the field, and then stabbing blindfold at the chart with a pencil. Scientists generally may well be expected to be uninterested in any such attempts.

That characters are "transmitted" in certain specific cases, namely, where certain characteristics of unicellular animals are concerned, Jennings has demonstrated. This search was useful because there an antecedent probability of the resemblance of cause and effect was revealed through expert knowledge of the genetic mechanism. With the higher animals no such mechanism has been discovered. The protection of the germ-cells is such that chemical factors alone can affect them, and there is an enormous gap between means to the production of a chemical effect in the body of the parent and the particular result which the chemical change will have in the germ-cells. Ultimate study of the chemistry of vital processes may in time indicate the effects of certain substances on the germ-cells, but there is as yet no body of information on that point, or on the chemical changes in the parent organism produced by various environmental factors and by bodily activities, competent to furnish the least basis for prediction.

There is, however, an aspect of the search for the "transmission of acquired characters" which is frequently overlooked, but which needs emphasis. The suggestion that such transmission may occur is drawn, in modern times at least, from the scheme of animal evolution. A simple and easy explanation of evolution is provided by the assumption that the adaptations an animal is forced to make to its environment affect, in some mysterious way, the structure of the animal's progeny, so that less individual adaptation is needed on their part. The postulate of sympathetic magic is here drawn upon to fill an embarrassing logical gap in biological theory. Most Lamarckians, apparently, are willing to stop here, but not all are so timid. If this is the true explanation of evolution, then there are superphysical causes at work in the world—causes of which science takes no cognizance. This is the implication of the "transmission of acquired characters" which most Lamarckians would glady deny, but which, in fact, is the real justification of their efforts.

If the mechanism of "transmission" is not through channels which can be accounted for in terms of chemistry and physical chemistry, then there are (if "transmission" is a fact) forces or entities at work which do not operate in the physical realm. If the "transmission of acquired characters" should be demonstrated for the higher vertebrates, we should be obliged to reconsider the subjects of divine intervention, telepathy and the whole gamut of "spirit manifestations" from a new point of view. Moreover, we should be obliged to admit that there is an actual foundation for the popular belief in sympathetic magic.

We admit that superstition always has its bases, although these bases are usually not such as would be easily recognized. Hence, psychologists and others have commonly lent an attentive ear and given largely of time and energy to alleged phenomena of the occult. The uniformity with which these phenomena vanish into thin air when subjected to investigation by rigorous laboratory methods has convinced us finally that there is nothing of value to be obtained in this direction. The "transmission of acquired characters" is, however, of a different order. The rats and rabbits are available in unlimited numbers. They do not refuse to work when their methods of procedure are uncovered. Experiments carried out in one laboratory can be repeated in others. This, then, is the obvious direction of work for those who are interested in the problem of a "supernatural" (or infranatural or endonatural) world. The skeptical scientists should not by any means discourage or scoff at these efforts. On the contrary, they should encourage and facilitate the investigations, for either positive or negative results are of value. But the investigations should be carried out with the cooperation of skeptics and under the observation of more than one technically qualified person. There is little use in guessing at flaws after results are reported.

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