task of taking the world at large into its confidence and friendship in a very real way, first by simplifying and popularizing or making fully intelligent to the public, all public, but not professional, reports. Second, by rearranging our geologic facts so as to bring into the foreground and limelight the great fundamental truths that all persons should know and recasting our text-books and teaching accordingly. Third, by striving to change geology from a history to a science, by the correlation of our facts into generalizations and, if possible, into definitely stated theories and laws. Fourth, by eliminating as far as possible all differences of interpretation and statement. Fifth, by encouraging the man who can dress our science up so as to attract and hold the interest of the world at large. Sixth, by following the Declaration of Independence in having "a decent respect for the opinions of mankind." That is the challenge. Will we meet it?

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PURPOSIVE ACTION[1]

IT is the purpose of this address to suggest certain directions in which a mechanistic explanation may be sought for the purposive behavior of animals, which has been by some authorities regarded as a unique phenomenon, irreducible to those laws which govern the rest of the universe.

Since I shall have occasion to speak of the motives or drives underlying behavior, it is not inappropriate to say that the drive which lies back of my present purpose is a hearty dislike of the doctrine of emergent evolution, which was so warmly endorsed at the last meeting of this association by Professor Jennings,[2] the retiring chairman of the Zoological Section. This doctrine, as you all know, holds that from time to time something entirely new emerges in the course of evolution. It is considered to be opposed to the doctrine of mechanism, which holds that from the beginning the material universe has been governed by a set of unchanging laws. Now as I read expositions of the doctrine of emergent evolution, it seems to mean either something with which all mechanists will agree, or something which involves the negation of scientific thinking and a return to more primitive modes of thought. First, it may mean that new phenomena make their appearance from time to time: new chemical combinations, new species of living beings. Who would doubt it? This is evolution: there is no need for the distinguishing adjective "emergent." Secondly, it may mean that new fundamental laws of the material universe have been discovered from time to time. Who would doubt this, or that others may yet be discovered which have been operating from the beginning but which our imperfect methods of observation have not previously been able to detect? Thirdly, it may mean that the fundamental laws of the universe modify each other when they enter into new combinations. Who would doubt it, or imagine that we have yet observed all the combinations of those laws which have existed from the beginning? Fourthly, it may mean that from time to time new fundamental laws of the physical universe have come into existence, and may at any time in the present or future do so. Professor Jennings complains that without emergent evolution there is no fun in experimenting. According to the mechanistic theory, he says, "from a sample of the universe we ought to be able to reason out the rest; the experimenters are those of us who can't"; and he goes on to say that this must naturally make the experimenter feel deeply inferior. But what would cheer the experimenter? The thought that he may at any moment observe a new combination and have the fun of showing that it is really reducible to already known laws? The mechanist gets a good deal of enjoyment from such an experience. Or the thought that he may at any moment discover a law which has been in operation always but has hitherto escaped observation? This is a joy for which the mechanist may always hope. Or is the only possible thrill for the experimenter to be derived from the chance that at any moment a new law of nature may *come into existence* and he be there to see? But what ought to discourage an experimenter more finally than such an expectation as this? He is trying to discover a law of nature, but what if at any moment it may be interfered with by a new one that has come into existence? If the universe can not be relied upon to stay on the tracks, why try to find out where the tracks lie? Professor Jennings sees in emergent evolution the only salvation from the dire practical consequences of mechanism. "Mingle," he says, "this perfect doctrine of mechanism with equal parts of the perfect doctrine of natural selection and you get a potion, a cocktail, with a kick that is warranted to knock out ethics and civilization." But if we believe that new laws of nature may at any moment begin to act, in the paralysis of science that would result from the drinking of *this* cocktail, I would give still less for the chances of ethics and civilization.

The mechanist then believes that whatever may be the ultimate truth of the matter, an inclination to

[1] Address of the vice-president and chairman of Section I—Psychology, American Association for the Advancement of Science, Nashville, December, 1927.

[2] SCIENCE, 65, 1927, pp. 19–25.

assume emergents in the sense of new forces should be held sternly in check. And it is the object of this paper to suggest how one of the emergents, namely purposive action, may conceivably be reduced to the status of a product of already existing forces.

The vitalist holds that living matter is fundamentally different from lifeless matter, and that its distinguishing characteristic is an emergent, namely purposiveness. As one reflects on the nature of a living body, it does seem to be distinguished from a lifeless body by a tendency to resist and compensate for disturbances of its pattern. It is composed of highly complex molecules, and these whether in living or lifeless bodies are likely to fall apart and disintegrate, thus changing the pattern of the whole. But in a lifeless body this disintegration is balanced by no reconstruction of molecules, while in a living body the pattern is constantly being restored. The actual materials of our bodies are constantly leaving us, but the pattern remains and new materials are forced into the same pattern, which is secured by all manner of devices; moreover, when the pattern can no longer be maintained, by all manner of devices its reappearance in offspring has been ensured. What is this that cares so much about its pattern? No wonder that the vitalist posits emergent entelechies, mysterious agencies that occupy themselves with its preservation. But to the mechanist mysterious agencies are too reminiscent of nature deities, earth spirits, and similar relics of the childhood of human thought to be congenial. And, he asks, is it really true that preservation and restoration of the pattern are peculiar to living matter? The atom also has a tendency to restore its pattern; whenever it loses an electron it makes haste to repair the loss. The mechanist would cling to the faith that the preservations and restorations, even the reproductions, of patterns in living organisms can ultimately be traced to the preservation and restoration of atomic patterns. And if it be said that this is merely to ascribe purpose to the atom, or perhaps to the electron, the mechanist will say, "Well and good; put whatever may be necessary into the beginnings of things, but don't be lavish with emergents during the later processes."

But vitalists in the field of psychology, like Professor McDougall, mean by purposiveness in living organisms more than a mere tendency to restore and reproduce the pattern. Professor McDougall means by purposiveness the organism's anticipation of the results of its action; the end is actually the cause of the action. The organism is not forced by physico-chemical laws to preserve and reproduce its pattern; the end to be attained produces the required behavior through a type of causality unknown to lifeless matter.

Now the means by which a living organism maintains its pattern may be divided into molecular activities, such as digestion and respiration, and mass activities such as movements of locomotion, seizing of food, and the like. The former are the province of the physiologist; in the latter, which constitute what is commonly called behavior, the psychologist has an interest, and it is to these that I shall henceforth confine myself.

Purposive behavior, in the sense of behavior objectively adapted to secure the continuance of the individual and the species, may be divided into inherited behavior and learned behavior. (We grant, of course, that the two constantly accompany each other). And it has been customary to include under inherited behavior the simple reflex response to a stimulus and the more complicated responses commonly called instinctive. Now the reflex looks mechanical. It seems, that is, to be dependent rather on the external stimulus plus the animal's physiological state than on any purpose in the animal's mind. And in fact Professor McDougall[3] grants freely that the reflex is mechanical, subject merely to the laws of physiological chemistry. This concession lands the vitalist in certain difficulties from which it takes considerable agility to escape. The first difficulty is that the reflex can be modified by learning, which would seem to obliterate any sharp distinction between it and higher forms of behavior, so that if you grant that the reflex is mechanical you will be put to it to show where mechanism ends and purposiveness begins. This difficulty Professor McDougall meets by asserting that the highly modifiable salivary reflex, for instance, is not a true reflex because it depends on the brain. Only behavior that depends on the brain, we then conclude, is purposive rather than mechanical; it would seem that the emergent "purposiveness" came into existence not with living matter but with the brain. The mechanist may indeed adduce, Professor McDougall says, the case of the frog with brain removed which, if it is prevented from wiping off a drop of acid from its skin with one leg, wipes it off with the other. This conduct looks purposive, but does not depend on the brain. Well, perhaps, Professor McDougall conjectures, in frogs and similar lowly animals purposive action does not depend on the brain.

The second difficulty created for the vitalist by the admission that reflexes are mechanical is that instinctive actions, which on McDougall's theory are manifestations of purposiveness, have been regarded as combinations of reflexes. This view of course must be rejected by the vitalist if the reflex is admitted to be mechanical. Instinctive action, the vitalist holds,

[3] "Outline of Psychology," New York, 1923, pp. 51–56.

is not a chain of reflexes but is guided by the idea of its end, as is shown by the fact that the means taken to secure the end is not mechanically fixed, another means being adopted if one means fails, as in the case of the frog just mentioned. Professor McDougall boldly accepts the consequence of this theory, and asserts that on the first performance of instinctive actions, for example, the first nest-building of a bird, the animal is guided by an inherited mental image of the nest; "the power of thinking of or imagining an object not present to the senses is provided in the form of innate mental structure."[4]

Most of us would hesitate to adopt such a hypothesis, and as a matter of fact F. H. Herrick's[5] careful studies of the instinctive behavior of birds, to which Professor McDougall nowhere alludes, indicate that it looks much more like a series of reflexes than like intelligent purpose. Through first-hand observation Herrick concluded that the series of activities beginning with the spring migration and proceeding through mating, nest-building, egg-laying, care of young in nest, care of young out of nest, and fall migration, is subject to disturbances inconceivable on a purposive theory; for instance, egg-laying sometimes anticipates nest-building, the eggs being laid on the ground, or the migration impulse interrupts the last egg-laying and the young are abandoned. In general when anything interrupts the normal course of instinctive behavior, the dislocated combination of acts that results has much more the aspect of machinery out of order than that of baffled attempts to realize a conscious purpose.

I think we may say that when by "purpose" is meant awareness of the object to be secured, the innate behavior of animals shows no satisfactory evidence of it. But if by purpose we mean merely *persistent striving,* the case is different. There does seem to be in the greater part of animal behavior something persistent, which underlies series of individual acts and unites them by a bond other than that of mere external association. This is shown alike in innate and in learned behavior. One of the most important results of experimental work on animals during the last ten years has been the evidence that animals will not learn without a motive; that a rat will not learn a maze with food in it unless he is hungry; and Szymanski[6] has shown that while various other motives, such as those resulting from uncomfortable surroundings or sex stimulation, will produce learning, a rat will run a given maze only under the influence of the motive that made him learn it. Our mistake as mechanists has been in trying to explain learning as an external linking together of separate acts into a series merely by their repetition. Watson's theory that in learning how to get out of a maze the errors are dropped off not because they involve delay in reaching the goal but because they are less frequently performed than the successful movements is probably the last effort of mechanism in this direction, and it is a failure.

The problem before mechanism in dealing with purpose is not merely to explain the association of transitory acts into series, but to furnish a mechanistic explanation of something that *endures throughout the series.* When in ordinary speech we say that a man has a purpose in what he is doing, we mean that there is something relatively constant throughout his course of action, namely awareness of an end, and when we watch animals engaged in instinctive activities, while their behavior shows that they are not aware of the end, it also shows the presence of something that persists until the end is reached. Can mechanism explain this relatively constant and unchanging factor, or must we make use of entelechies, innate ideas, and other regressions into past modes of thought?

Surveying the physiological possibilities, we find among our bodily processes two types of relatively constant and persistent states, not usually thought of as purposive, and offering no essential obstacle to a mechanistic explanation. The first type comprises internal physiological conditions such as hunger, thirst, fatigue and certain states of the sex organs. The second type includes bodily attitudes, due to the continuous innervation of certain external muscles. Compared to actual movements, both internal physiological states and external bodily attitudes have the character of relative permanence. If we can show that they are involved in purposive action, we shall have a possible mechanistic theory of its essential feature.

The inner physiological states present themselves as the appropriate basis for the motives or drives. The physico-chemical equilibrium of the body is disturbed, either by the lack or by the excess of some important substance. While this condition continues, energy is set free and finds a natural outlet in bodily movement. And movement will continue until the condition ceases, either by restoration of the physiological balance or by the counteracting influence of fatigue. If the external situation is one that has been often encountered, the movements may be adapted either innately or by previous learning to rapid relief of the physiological disturbance, and we

[4] *Op. cit.* p. 202.

[5] *The Popular Science Monthly,* 76, 1910, pp. 532–556, 77, 1910, pp. 82–97, 122–141.

[6] *Pflüger's Archiv,* 171, 1918, p. 374.

say that the animal has acted reflexly, instinctively, or according to habit. If such preformed pathways are not opened, the energy of the physiological state discharges into a wider variety of movements; an animal in a new situation such as a maze runs down all the passages and makes all the turnings possible. Experiments indicate that in maze learning it is the movements nearest the "success" that are earliest learned; that is, while the drive, the persistent physiological state, say, of hunger, becomes associated with all the movements that occur while it lasts, it is most strongly associated with those movements that occur nearest its end. To explain why this should be so, the mechanist can appeal to the established laws of association; the drive will naturally form strongest associations when it is itself strongest, and this of course is when it is nearing its end; further, at the beginning of a repetition of the situation the movements made at the end of the preceding series have the advantage of recency. By the prepotency, thus grounded, of the movements nearest in time to the cessation of the drive, it is possible to explain learning by trial and error; but *only through the influence of the drive* which accompanies the whole series.[7]

Thus with no assumption of conscious awareness of purpose on the animal's part we may hope to explain through the persistent influence of drives the organization of movements into new combinations leading to the cessation of the drive. But what about those cases, common in human behavior, where there *is* awareness of purpose? A man, under the influence of a drive which can not at once be relieved, sometimes works off the impeded energy in random movements as an animal does, but it is his human birthright to think the situation out, guided in his thought by the influence of the *idea* of his goal. This is the climax, the crucial point of the contest between vitalism and mechanism for the explanation of purposive action. Here the idea of the end is actually present, though not continuously present, in consciousness, and not only the idea of the ultimate end, but the idea of means to that end. For this state of affairs the mechanist must conceive a physiological basis capable of being explained on physico-chemical laws.

Why should not the mechanist, who of course holds that a definite nervous process underlies the idea of the end, merely say that this nervous process is the cause of consciously purposive action? Because if we can judge the nervous process underlying ideas from the behavior of ideas themselves, they lack that character of *persistence* which is essential to purposive action. Ideas are essentially transitory: it is impossible for one to endure without change for more than a few seconds. They may recur, but they can not last. Introspective observation of the process of consciously purposive action has shown that the idea of the end to be gained, while present at the outset, may disappear many times during the course of the action or thought without interrupting progress towards the end. The attempt to use the nervous substrate of an idea to explain a coherent series of reactions fails for the same reason that the old mechanistic explanation of learning as an external linking of separate and transitory movements fails: in both cases we must have an underlying process to hold the series together. But in consciously purposive action this underlying process must not only be *persistent,* like the uneasiness of a drive: it must be, so to speak, *constant in direction.*

It was said a little while ago that there are two types of bodily processes which possess that character of relative permanence which is needed for the physical substrate of purposive action: internal bodily states, in which class the drive or motive belongs, and external bodily attitudes.

Now if we watch a man who, when he can not get relief from the influence of a drive by immediate action, begins to think the matter out, we observe that he becomes quiet, that his restlessness ceases. If we are that man, introspection tells us that our quiet is not the quiet of relaxation but that of bodily tenseness, especially in the trunk muscles. Whenever this attitude relaxes, the energy of the drive begins again to escape in random movements; we stop thinking and become restless.[8] For all purposive action there must be a persistent inner physiological state of imbalance, the drive. For purposive *thinking,* we may conjecture that this state must discharge its energy not into immediate action, whether useful or merely random restlessness, but into a quiet, tense bodily attitude. And any idea may become a purpose, the idea of an end, if, being first associated with a drive, it becomes associated with this peculiar, persistent attitude of tense quietness.[9]

Not only does this motor explanation of purposive action seem to me plausible, but I believe we can trace in animal behavior a stage intermediate between the adaptation of acts to ends which occurs by random movements and requires only the persistent influence of the drive, inducing restlessness, and that which occurs by thinking the problem out, under the influ-

[7] M. F. Washburn, "The Animal Mind," 3rd edition, 1926, 329–337.

[8] It was Münsterberg who first suggested in his doctor's thesis, "Die Willenshandlung," that the feeling of activity or effort, the will-consciousness, consists of kinesthetic sensations from our bodily attitude.

[9] M. F. Washburn, "Movement and Mental Imagery," 1916, Chapter 8.

ence of a bodily attitude of quiet tension. Many observers of the behavior of animals in learning a maze have noted that they quickly acquire a bodily orientation towards the center, and tend to correct movements that carry them away from this oriented attitude. Similarly with Hunter's Delayed Reaction apparatus, even when the animals were restrained from going to the correct door for some little time after the signal light had been turned off, they succeeded in doing so by keeping their noses pointed during the delay interval towards the place where the light had been. The original stimulus for this oriented attitude is of course external, the light, or the smell of food in the maze; but the orientation seems to be capable of persisting for some time after the stimulus is gone, and to be revived by associated stimuli, as when a dog entering a room looks under the chair where he left a ball. Following our general custom of deriving our terms for abstract relations from terms meaning spatial relations (as when we speak of "straightening out" a mental puzzle), we use the expression "thought *directed toward a goal.*" May not the steadily tense bodily attitude accompanying directed thought be in some sense a relic of the orientation in lower animals of the entire body towards the stimulus that will bring relief from a drive? In the beginning, while the reflex and tropism were adequate modes of behavior, the drive discharged in a definite direction. As the environment became more complex, the drive discharged into random movements of which those associated with the drive in its last and most intense stages tended to survive and become organized into systems. In this process the drive secured the persistence needed for purposive action, but the definite direction of the tropism was lost. Often, however, in animals, part of the energy of the drive goes into the tendency to maintain and restore a bodily orientation towards the goal; while in man, for whose varied activities general bodily orientation is too confining, directed thinking is sustained by a vestige of this general bodily orientation, the tense quietness of the trunk muscles that may persist even when we turn from one position to another.

In explaining, then, the persistent character of purposive action, the mechanist may substitute for the vitalist's mysterious, emergent entelechy, involving something over and above the ordinary physico-chemical laws, the *drive* as a state of unstable physico-chemical equilibrium, underlying all purposive action, and an attitude of steady contraction of the trunk muscles, into which the energy of the drive may discharge and which accompanies the higher forms of purposive action. These suggestions towards a mechanistic explanation of purposiveness have had to be put concisely and dogmatically because of the limits of my time. If they are highly speculative, they are at least, it seems to me, by virtue of being mechanistic, closer to the spirit of science than the semi-personal and animistic emergents of the vitalist.

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THE COLLECTING OF FOLK SONGS BY PHONOPHOTOGRAPHY[1]

Ear analysis of folk music. The traditional method of the anthropologist in collecting folk or primitive music has been an analysis of the songs by ear, whether taken directly from the lips of a singer or from a phonograph record. This subjective method has many serious limitations.

That the ear is inadequate to describe many of the important elements of music is best indicated by the American Negro vocal embellishments, whose description has baffled the keenest ear. The fast changes of the voice lose their original identity when heard, becoming fused in perception. Another difficulty with a subjective analysis is the bias due to past musical experience which deafens the notator to elements foreign to his own music. For example, the European musician holds that American Negro music belongs to his musical system, while the African analyzes out of the great sound complex reaching his ear so much in common with his own music and so little that is not that he draws a natural but opposite conclusion.

Conventional notation. The conventional symbols which have been used by collectors of folk music were devised as a representation of European music. Consequently to use such symbols neglects those factors which might make a folk music distinctive. In Negro music, that part which is characteristically Negro is not found in the stilted notes on the conventional five-line staff, but rather in the twists and slides between the lines.

Measurable records of music. In the fall of 1925 we undertook a field study of Negro music, but instead of using the cylinder phonograph we substituted a portable phonophotographic camera. The voices of Negroes were photographed on motion picture film, by using an optical lever somewhat on the order of Miller's phonodeik.[2] This photographic method shifted the analysis of folk songs from auditory experience to an objective measurable record of the sound wave.

[1] Presented before the National Academy of Sciences, at Urbana, Illinois, October 18, 1927.

[2] Miller, D. C. "The Science of Musical Sounds." Macmillan, New York, 1916.