A BIOLOGICAL BASIS FOR TELEOLOGY[1]

EDMUND W. SINNOTT

Yale University

Most of the contributions of biology to psychology have tended to strengthen the deterministic character of psychological concepts. If one regards a living organism as a physico-chemical mechanism, no different in its fundamental operation from any complex machine, there is obviously little room in it for "mind" or for such rather nebulous concepts as purpose or value. At most, these seem to be subjective experiences of happenings in a purely physical system and to have no effect on what the system does. Behavior is the over-all activity of such a mechanism and motivation is interpreted as the same sort of "drive" that powers any machine. Psychology from this point of view is to be regarded as a kind of physiology.

Whatever one's philosophical position may be as to the relation between the mental and the physical aspects of man, he must respect this tough-minded approach to the problems of mind. In biology, mechanistic assumptions have proven very fruitful as a means of learning about the character and activity of living things and they provide a truly scientific method of attack upon such problems. It would be disquieting indeed if we should discover that either life or mind violated the magnificent orderliness of nature and introduced into it an element of arbitrariness or caprice.

The biologist's zeal to interpret life in mechanistic terms, however, and the psychologist's enthusiasm in accepting these as the basis of his own science have led both to oversimplify their problems somewhat. Life is not merely a succession of separate chemical processes, and behavior is more than a series of reactions to stimuli. Something further is involved, something normative and regulatory. A clue as to what this is comes from the basic fact of the life sciences, *biological organization*.

Regulation in Development

The distinctive feature of life is that it makes organisms—organized systems in which each part is related to the rest in an integrated

[1]This paper is a digest of a Sigma Xi lecture at the University of Vermont, December 11, 1956.

whole. If biology is an autonomous science and anything more than a sort of glorified chemistry, this is what makes it so. Embryology, from egg to adult, is a progression through a precise series of organized developmental stages to the mature individual. This individual in some way is prefigured in the egg itself, and development proceeds as to an end. The end in organic development is not reached by a single linear series of preformed steps, however, like the succession of frames in a motion-picture film, each of which follows the one before it as the picture unfolds. The end is rather the dominant element in the whole proceeding and seems to be immanent throughout the organism. We infer this because if normal development is disturbed or the mature individual injured, the organism shows a persistent tendency to reach the same end, a normal whole. This end may be achieved in a manner very different from the normal one, through a process of self-regulation. This is what Driesch called *equifinality*, the similarity of the ends.

Countless instances of such regulation have been reported by students of morphogenesis and experimental embryology. If an angleworm is cut in two, the head end will form a new tail. Legs removed from a crab will be replaced. Almost any bit of a planarian worm or of a hydroid, if isolated, will regenerate a whole. A plant shoot, cut off and with its base placed in moist sand, will form a new root system. Such cases are commoner in more primitive organisms than in those higher in the evolutionary scale. Embryonic structures show them much oftener than adult and fully differentiated ones, which gradually lose their early potencies; but this tendency to replace missing parts so that a complete whole is restored is general among living things and is the most remarkable fact of biology.

Regeneration is not limited to large structures but may be shown by single cells. In many animals, such as sea urchins or amphibia, if the first two cells of the embryo are separated from each other, each will grow into a whole individual instead of into a half of one. In some plants, cells from the mature leaf epidermis or other parts may be induced to start growth again and will then form small buds from which mature plants develop. In the "Live-forever" the production of little plantlets thus formed along the edge of the leaf is the natural method of vegetative reproduction. If proper conditions could be found, it is probable that any cell, brought back to its embryonic state, would be able to produce the whole organism. Such a result should not be surprising for this is what a fertilized egg does, and every

cell presumably has the same complement of chromosomes (or a multiple of it) as is found in the egg from which it came.

The point is that in every part of an individual, and probably in every one of its cells, there is something that *represents the whole organism*. This is more than the complement of genes, for it coordinates the action of these thousands of hereditary units, each affecting some process in the whole, in such a way that they do not interfere with each other but proceed in an orderly series of steps, in normal development or in regeneration, to a mature state characteristic of a particular species. What this omnipresent coordinating and normative mechanism is we have as yet no idea. To this norm, by a process of self-regulation, the development of the whole conforms. In some way the norm presides, so to speak, over the development of the organism. The norm directs this, though sometimes by a course very different from the usual one, to the same conclusion, as though the moving-picture film of which we spoke were cut and the first part then proceeded to complete the story even though the last were missing.

REGULATION IN PHYSIOLOGY

This ability of protoplasm to regulate its activities to norms set up within it can be observed in function as well as in development, and is familiar as the process of homeostasis. It is particularly evident in the physiology of the higher animals where body temperature, blood sugar, and many other characters are precisely regulated. Here is the basis of that "widsom of the body" about which Prof. W. B. Cannon wrote, that *vis medicatrix naturae* which so often restores when illness strikes.

Some of the mechanisms concerned in the attainment of these physiological norms are beginning to be known. It is significant that, in many cases, if one mechanism does not operate, another is called into play which leads to the same result, so that we may speak of physiological equifinality. Individual processes are not independent in physiology, however, any more than individual organs are independent in embryology, but each in some way is geared into the others. The ultimate norm is a successfully functioning whole organism. Form and function cannot be separated. They are both activities of protoplasm, and it is reasonable to believe that the normative mechanism in one, whatever it turns out to be, is the same sort of mechanism as in the other.

Regulation in Behavior

The fact of particular interest for the topic we are discussing is that *behavior* is also self-regulatory and normative. One can draw no sharp line between developmental processes, by which lifeless matter is built into the body of the organism; physiological processes, by which the inner activities of this body are regulated; and behavioral processes, manifest in the over-all activities of the whole organism. All of these in final analysis are manifestations of protoplasmic activity. It should not be surprising, therefore, that behavior is normative and that it conforms to ends set up in the living system which may be compared to those operative in embryology and physiology. Instinct, the simplest sort of animal behavior and which may even have its beginnings in plants, is clearly regulatory. By it the organism moves from an unfavorable to a favorable environment and carries out a host of activities which aid in its successful survival and reproduction.

In behavior there is also the same sort of equifinality that has been noted in embryology and physiology. It is significant that almost every instinctive act is carried out under a different series of conditions. The climbing of a pea plant on a bit of brush (really behavior); the seizure of its prey by a dragon-fly; the building of an oriole's nest, all are instinctive performances, the basis for which is present in the nervous system or in the body as a whole, but which reach their accomplishment through a series of acts which is different every time. The norm is the same, but the method of reaching it varies.

Regulation and Purpose

A number of biologists and others have noted the resemblance between the directiveness of these lower organic activities and that purposiveness which in man is a psychical process. It is interesting that Spemann, the distinguished embryologist, comes to this conclusion. "These processes of development," says he, "like all vital processes, are comparable, in the way they are connected, to nothing we know in such a degree as to those vital processes of which we have the most intimate knowledge, viz. the psychical ones"(6, p. 371).

The British zoologist E. S. Russell agrees: "The directiveness of vital processes is shown equally well in the development of the embryo as in our own conscious behavior. It is this directive activity shown by individual organisms that distinguishes living things from inanimate objects" (2, pp. 178-179).

A man of letters, Herbert J. Muller, puts it thus: " 'Purpose' is not imported into nature, and need not be puzzled over as a strange or divine something else that gets inside and makes life go; it is no more an added force than mind is something in addition to brain. It is simply implicit in the fact of organization and is to be studied rather than admired or 'explained' " (1, p. 109).

Such comments show that for the biological processes of embryology and physiology and for the instinctive behavior that grows out of them, a teleological interpretation is certainly defensible. In all there is a norm, planted in living stuff, to which as to an end the self-regulating activity of an organism conforms. These are all unconscious processes, in the general sense of that term; but a conscious purpose in man, it seems to me, is simply the inner subjective *experience* of this regulatory process. How consciousness arises is another problem. As good evolutionists we shall find it very difficult to draw a sharp line between our own purposiveness, that of the higher mammals to which it is so clearly related, and thus down the line to the single-track goal-seeking of the embryo—the striving of a blastula, as Joseph Needham says, to grow into a chicken. A conscious purpose, developed from biological beginnings of this sort, need involve no mysterious final cause, no effect of the future on the present, no violation of the orderliness of nature. It is open to as mechanistic an explanation as any other vital activity.

Such an interpretation of purposive behavior can answer the vigorous objections frequently raised by biologists to the idea of any purposiveness among living things and restore this concept to its rightful place as the very essence of life itself.

What has given the word "purpose" its bad repute is its frequent abuse by unskilled teachers, particularly in elementary classes. To dramatize life processes they sometimes thoughtlessly speak of a plant or animal as though it were "trying" to do what was best for itself. A root grows downward "for the purpose" of reaching water in the soil. When a stem bends toward the light it is "attempting" to get its leaves into a position favorable for photosynthesis. The hummingbird puts lichens on the outside of its nest "in order that" this may be inconspicuous. The "purpose" of the floral mechanisms of many plants is to ensure cross-pollination. The snowshoe rabbit's broad feet are "intended" to support him on the snow.

The fact that most of the reactions and most of the bodily structures of plants and animals are such as to favor the successful life of

the individual and its species suggests to one who does not know the facts that living things have a natural power to do what is best for them and are continually trying to exercise that power. They are thought of as attempting to react to their environment as a person would. Indeed, this concept was one of the elements in Lamarck's theory of evolution. Such anthropomorphism is clearly erroneous and gives the student an entirely wrong idea of living things, for natural selection seems able to account for the remarkable adaptations which are everywhere around us. It is this sort of "purposiveness" to which biologists rightfully object.

The goal-seeking of which I have spoken is quite a different matter. It involves, in its simpler manifestations, neither consciousness nor intelligence. It *does* involve activity toward an end, but this end need have no relation to its usefulness to the organism. Vestigial wings are the embryological goal for a well-known mutant of *Drosophila*, but flies of this sort would have little chance for survival if left to themselves. Waltzing is normal behavior in certain domesticated races of mice but would be a severe handicap in the wild. Only those goals, developmental or behavioral, that have been winnowed out by the selective processes of evolution have survived. If an organism seeks some different end, its behavior is still entirely purposeful but its career is likely to be short. If this distinction is made clear to the student, he will be on his guard against the false sort of teleology and will come to recognize that in a real sense an organism is normative, both in its growth and in its behavior, and that this is actually an essential quality of life at every level.

Regulation and Mind

Objection may still be offerred to this sort of teleology because of its other implications. If biological goal-seeking has evolved into conscious purpose, clearly a psychical phenomenon, this means that the beginnings of mind are to be sought throughout all life and that life and mind are coextensive. Far from being objectionable, it seems to me that this conception offers a very hopeful method of approach to the ancient mind-body problem. Under it mind may be defined as *whatever directs the development and activity of an organism in conformity to norms set up within its living stuff*. For human behavior, these are established in the brain. A purpose yet to be accomplished, and thus other psychical acts, presumably have the same *sort* of

physical correlate in the cells of the brain as the mature animal has in the egg from which it will develop.

It may be objected also that reason and abstract thought are so far removed from embryological activities that they are different in kind. To this one may reply that all ideas at first were purposes; that goals continually change (as they do in development if the environment is altered); and that, instead of resulting in bodily acts, they may lead to such mental ones as desire, value judgement, and finally abstract thought itself. Space is lacking to discuss further the suggestions here presented, but a substantial argument can be built up for them. The present writer has elsewhere endeavored to do this (3, 4, 5). By regarding body and mind, protoplasmic activity in development and in behavior, as two aspects of the same underlying biological process— organized self-regulation—a monistic position is possible which does not sacrifice either of these aspects of man to the other.

This idea has further implications that are important in psychology. It emphasizes the organism, the organized and integrated individual, as an essential concept and thus provides a biological basis for the *self*. The self is a homeostatic living system, "an elaborate pattern of desired constant states which are protected if anything threatens them" (7, p. 18). Indeed, psychology itself has been defined as the study of those homeostatic processes which involve the whole organism. Thus biology can offer support for an old concept that is now coming back into favor. Its philosophical implications are evidently important.

MOTIVATION AS GOAL-SEEKING

For an understanding of *motivation* the fact of biological organization may also be significant. The idea commonly associated with motivation in psychology today is that of "drive." Drives are assumed to direct behavior, relieve tensions, and meet needs. But the implication of the word "drive," tacit or explicit, is that energy is here released which moves the organism to action; that the organism is impelled, so to speak, just as a machine is impelled. A motive drives an individual in fundamentally the same way that power from gasoline drives a car. This is entirely in harmony with the mechanistic conceptions brought over from biology.

The idea of biological regulation and goal-seeking, however, presents a somewhat different picture of motivation by suggesting that

the direction of the process is not that which is commonly proposed. Living things—including man— seem not to be pushed into action from behind, so to speak, but to be drawn toward goals they seek. Hence the importance of teleology. In familiar terms this means that we do something because we *want* to do it and not because we are driven to do it. Such a concept has the merit of being in harmony with the verdict of common experience, for in most of our acts (save in abnormal cases) it seems to be desire rather than compulsion that determines what we do.

This, I believe, is more than a semantic difference, for it involves the whole orientation of the process. It suggests that educators and all those who seek to guide man's actions should depend not only on the compulsions of law and the persuasions of rational argument, but should seek especially to mold his desires, purposes, and aspirations. This idea gains particular importance when we remember that man's advance has now been shifted from the biological to the cultural level. The so-called progress of civilization is simply in our minds, not our germ plasm, and cannot be transmitted to our offspring by breeding. Whatever progress has been made must be passed on from one generation to the next by education. Equally important, whatever progress we shall achieve in the future must depend on elevating the goals we seek and strengthening the motive power that draws us to them.

The Basis of Regulation

In all this one needs to remember that such motivation, like biological teleology, need not imply anything immaterial or non-scientific. Admittedly, the mechanics of the self-regulatory process, both in embryo and brain, is quite unknown. Various suggestions, none of them very persuasive, have been made to account for it. Organic regulation has been compared to the feed-back processes in electronic calculators; to the Principle of Le Chatelier that physical systems under stress return to their original state when the stress is removed; to the Exclusion Principle of Pauli, which states that the orbit of each electron in an atom is related to the other orbits; to the operation of biological fields; to the principle of coding in Information Theory, and to various others.

Just what *is* the material correlate of a goal or norm? Something must be present in the developing organism, and presumably in every cell, which specifically represents the whole organism but is usually

latent and not called upon to display its potencies. Is this a pattern of particles and processes implanted in the living stuff? We might compare it, perhaps, to the patterned surface of a phonograph record which, if called upon, will "regenerate" a melody. An even closer analogy would be to Claude Shannon's electronic mouse which unerringly finds its way through a maze, once this has been "learned." Something representing the form of that particular maze—a "purpose" to run through it, if you will— is embedded in the mouse's structure. This is only an analogy, at best, but a study of it and of other complex electronic mechanisms that are so important in modern technology may give us a clue, as Norbert Wiener believes they will, to the processes going on in the nervous system. A pattern of some sort must be present there, conformity to which regulates the behavior of the organism. What this pattern is constitutes one of the major problems of psychology.

It should be recognized that this pattern is continually changing. Embryonic norms are relatively rigid, but even these may be quite different under different environments. Behavioral norms, particularly in animals, are far more fluid since the environment often alters radically. Under different conditions a bird may seize an insect, seek a mate, build a nest or elude a predator. The goals to which it regulates its behavior are different in each case, and its psychical life is richer than that of simpler organisms.

The norms of purposive behavior in man are far more complex and various than those of any other organism. How they are established and what decides the direction they will take, involves the whole problem of freedom and determinism. If man is a pure mechanism, his goals are all determined for him and his apparent freedom is illusion. If what he *is*, is essentially a bundle of purposes and desires, however, perhaps the ancient problem of freedom is meaingless, for purpose and purposer are the same, and he obviously does what he wishes to do.

However this may be, we must admit, I think, that life everywhere, from its simplest beginnings to man, is a *creative* process, continually setting up new goals, bodily or behavioral, to be reached. The lifeless world produces the same things over and over again, but life is continually pressing forward to something new. This creative process reaches its climax in the imaginative power of man, which may perhaps be looked upon as the highest expression of biological teleology.

Here, of course, we are in a field where almost nothing is certainly known and where it is easy to slip over the border from biology and psychology to metaphysics and philosophy. The only purpose of the present paper is to suggest a basis in the life sciences for a teleology that seems to be strictly scientific and which, if sound, has certain important implications for psychology. The foundations of it can perhaps be examined more directly by the student of morphogenesis than by the student of behavior. At least the biologist and the psychologist should join their forces more closely than in the past for an attack upon it. The final answer will doubtless not be gained until we understand the real nature of life itself.

References

1. Muller, H. J. *Science and criticism.* New Haven: Yale University Press, 1943.
2. Russell, E. S. *The directiveness of organic activities.* Cambridge, England: University Press, 1945.
3. Sinnott, E. W. *Cell and psyche; the biology of purpose.* Chapel Hill, N. C.: University of North Carolina Press, 1950.
4. Sinnott, E. W. *The biology of the spirit.* New York: Viking Press, 1955.
5. Sinnott, E. W. *Matter, mind and man.* New York: Harper, 1957.
6. Spemann, H. *Embryonic development and induction.* New Haven: Yale University Press, 1938.
7. Stagner, R., & Karwoski, T. F. *Psychology.* New York: McGraw-Hill, 1952.