Ludwig von Bertalanffy

passages from

General System Theory

(1968)

<u>Note</u>
Ludwig von Bertalanffy (1901-1972) has been on of the most acute minds of the XX century. Here is a miscellanea of passages from his General System Theory. The first part of the text focuses on the function of the theory of systems and on the main features of closed and open systems. The second part presents a conception of the human being not as a robot or a moron aiming at reducing tensions by satisfying biological needs, but as an *active personality system* creating his own universe, who revels in accepting challenges, solving problems and expressing his artistic inclinations.

<u>The Quest for a General System Theory</u>

There exist models, principles, and laws that apply to generalized systems or their subclasses, irrespective of their particular kind, the nature of their component elements, and the relation or 'forces' between them. It seems legitimate to ask for a theory, not of systems of a more or less special kind, but of universal principles applying to systems in general.
In this way we postulate a new discipline called *General System Theory*. Its subject matter is the formulation and derivation of those principles which are valid for 'systems' in general.

A consequence of the existence of general system properties is the appearance of structural similarities or isomorphisms in different fields. There are correspondences in the principles that govern the behaviour of entities that are, intrinsically, widely different. To take a simple example, an exponential law of growth applies to certain bacterial cells, to populations of bacteria, of animals or humans, and to the progress of scientific research measured by the number of publications in genetics or science in general.

System isomorphisms also appear in problems which are recalcitrant to quantitative analysis but are nevertheless of great intrinsic interest. There are, for example, isomorphies between biological systems and 'epiorganisms' like animal communities and human societies.

It seems therefore that a general system theory of systems would be a useful tool providing, on the one hand, models that can be used in, and transferred to, different fields, and safeguarding, on the other hand, from vague analogies which often have marred the progress in these fields.

The isomorphism under discussion is more than mere analogy. It is a consequence of the fact that, in certain respects, corresponding abstractions and conceptual models can be applied to different phenomena. Only in view of these aspects will system laws apply. This is not different from the general procedure in science.

There is, however, another and even more important aspect of general system theory. Concepts like those of organization, wholeness, directiveness, teleology, and differentiation are alien to conventional physics. However, they pop up everywhere in the biological, behavioural and social sciences, and are, in fact, indispensable for dealing with living organisms or social groups. Thus, a basic problem posed to modern science is a general theory of organization. General system theory is, in principle, capable of giving exact definitions for such concepts and, in suitable cases, of putting them to quantitative analysis.

Aims of a General System Theory

While in the past, science tried to explain observable phenomena by reducing them to an interplay of elementary units investigable independently of each other, conceptions appear in contemporary science that are concerned with what is somewhat vaguely termed 'wholeness', i.e. problems of organization, phenomena not resolvable into local events, dynamic interactions manifest in difference of behaviour of parts when isolated or in a higher configuration, etc.; in short, 'systems' of various order not understandable by investigation of their respective parts in isolation. Conceptions and problems of this nature have appeared in all branches of science, irrespective of whether inanimate things, living organisms, or social phenomena are the object of study.

Not only are general aspects and viewpoints alike in different sciences; frequently we find formally identical or isomorphic laws in different fields. In many cases, isomorphic laws hold for certain classes or subclasses of 'systems', irrespective of the nature of the entities involved. There appear to exist general system laws which apply to any system of a certain type, irrespective if the particular properties of the system and of the elements involved.

General System Theory, therefore, is a general science of 'wholeness'.

(1) There is a general tendency towards integration in the various sciences, natural and social.

(2) Such integration seems to be centred in a general theory of systems.

(3) Such theory may be an important means of aiming at exact theory in the nonphysical fields of science.

(4) Developing unifying principles running 'vertically' through the universe of the individual sciences, this theory brings us nearer to the goal of the unity of science.

(5) This can lead to a much-needed integration in scientific education.

Closed and Open Systems

Conventional physics deals only with closed systems, i.e. systems which are considered to be isolated from their environment.

However, we find systems which by their very nature and definition are not closed systems. Every living organism is essentially an open system. It maintains itself in a continuous inflow and outflow, a building up and breaking down of components, never being, so long as it is alive, in a state of chemical and thermodynamic equilibrium but maintained in a so-called steady state which is distinct from the latter.

It is only in recent years that an expansion of physics, in order to include open systems, has taken place. This theory has shed light on many obscure phenomena in physics and biology and has also led to important general conclusions of which I will mention only two.

The first is the principle of equifinality. In any closed system, the final state is unequivocally determined by the initial conditions: e.g. the motion in a planetary system where the positions of the planets at a time t are unequivocally determined by their positions at a time t°.
This is not so in open systems. Here, the same final state may be reached from different initial conditions and in different ways. This is what is called equifinality.

Another apparent contrast between inanimate and animate nature is what sometimes was called the violent contradiction between Lord Kelvin's degradation and Darwin's evolution, between the law of dissipation in physics and the law of evolution in biology. According to the second principle of thermodynamics, the general trend of events in physical nature is towards states of maximum disorder and levelling down of differences, with the so-called heat death of the universe as the final outlook, when all energy is degraded into evenly distributed heat of low temperature, and the world process comes to a stop. In contrast, the living world shows, in embryonic development and in evolution, a transition towards higher order, heterogeneity, and organization. But on the basis of the theory of open systems, the apparent contradiction between entropy and evolution disappears. In all irreversible processes, entropy must increase. Therefore, the change of entropy in closed systems is always positive; order is continually destroyed. In open systems, however, we have not only production of entropy due to irreversible processes, but also import of entropy which may well be negative. This is the case in the living organism which imports complex molecules high in free energy. Thus, living systems, maintaining themselves in a steady state, can avoid the increase of entropy, and may even develop towards states of increased order and organization.

Information and Feedback

Another development which is closely connected with system theory is that of the modern theory of communication

The general notion in communication theory is that of information. In many cases, the flow of information corresponds to a flow of energy, e.g. if light waves emitted by some objects reach the eye or a photoelectric cell, elicit some reaction of the organism or some machinery, and thus convey information.

There is, however, another way to measure information, namely, in terms of decisions.

A second central concept of the theory of communication and control is that of feedback.

Feedback arrangements are widely used in modern technology for the stabilization of a certain action, as in thermostats or in radio receivers; or for the direction of actions towards a goal where the aberration from that goal is fed back, as information, till the goal or target is reached.

There is indeed a large number of biological phenomena which correspond to the feedback model. First, there is the phenomenon of so-called homeostasis, or maintenance of balance in the living organism, the prototype of which is thermoregulation in warm-blooded animals.

Causality and Teleology

We may state as characteristic of modern science that this scheme of isolable units acting in one-way causality has proved to be insufficient. Hence the appearance, in all fields of science, of notions like wholeness, holistic, organismic, gestalt, etc., which all signify that, in the last resort, we must think in terms of systems of elements in mutual interaction.

Similarly, notions of teleology and directiveness appeared to be outside the scope of science.

Nevertheless, these aspects exist, and you cannot conceive of a living organism, not to speak of behaviour and human society, without taking into account what variously and rather loosely is called adaptiveness, purposiveness, goal-seeking and the like.

The System Concept

In dealing with complexes of 'elements', three different kinds of distinction may be made – i.e.,

(1) according to their *number*;

(2) according to their *species*;

(3) according to the *relations* of elements.

A system may be defined as a set of elements standing in interrelation among themselves and with environment.

Progress is possible only by passing from a state of undifferentiated wholeness to a differentiation of parts.

We term a system 'closed' if no material enters or leave it; it is called 'open' if there is import and export of material.

Living systems are not closed systems in true equilibrium but open systems in a steady state.

An open system is defined as a system in exchange of matter with its environment, presenting import and export, building-up and breaking-down of its material components.

Life and tension

Biologically, life is not maintenance or restoration of equilibrium but is essentially maintenance of disequilibria, as the doctrine of the organism as open system reveals. Reaching equilibrium means death and consequent decay. Psychologically, behaviour not only tends to release tensions but also builds up tensions; if this stops, the patient is a decaying mental corpse in the same way a living organism becomes a body in decay when tensions and forces keeping it from equilibrium have stopped.

There is a wide range of behaviour – and presumably also of evolution – which cannot be reduced to utilitarian principles of adaptation of the individual and survival of the species. Greek sculpture, Renaissance painting, German music – indeed, any aspect of culture – has nothing to do with utility, or with the better survival of individuals or nations.

Also the principle of stress, so often invoked in psychology, psychiatry, and psychosomatics, needs some reevaluation. As everything in the world, stress too is an ambivalent thing. Stress is not only a danger to life to be controlled and neutralized by adaptive mechanisms; it also creates higher life.

If life after disturbances from outside, had simply returned to the so-called homeostatic equilibrium, it would never have progressed beyond the amoeba which, after all, is the best adapted creature in the world – it has survived billions of years from the primeval ocean to the present day. Michelangelo, implementing the precepts of psychology, should have followed his father's request and gone in the wool trade, thus sparing himself lifelong anguish although leaving the Sistine Chapel unadorned.

Life is not comfortable setting down in pre-ordained grooves of being; at its best, it is *élan vital*, inexorably driven towards higher forms of existence.

System-Theoretical Re-orientation

It is along such lines that a new model or image of man seems to be emerging. We may briefly characterize it as the model of man as *active personality system*.

The system concept tries to bring the psychophysiological organism as a whole into the focus of the scientific endeavour.

In contrast to the model of the reactive organism expressed by the S-R [stimulus-response] scheme – behaviour as gratification of needs, relaxation of tensions, reestablishment of homeostatic equilibrium, its utilitarian and environmentalistic interpretations, etc. – we come rather to consider the psychophysical organism as a primarily active system.

I, for one, am unable to see how, for example, creative and cultural activities of all sorts can be regarded as 'response to stimuli', 'gratifications of biological needs', 'reestablishment of homeostasis', or the like.

Man is not a passive receiver of stimuli coming from an external world, but in a very concrete sense *creates* his universe.

Beyond the mass robot

The concept of man as mass robot was both an expression of and a powerful motive force in industrialized mass society. It was the basis for behavioural engineering in commercial, economic, political and other advertising and propaganda; the expanding economy of the 'affluent society' could not subsist without such manipulation. Only by manipulating humans ever more into Skinnerian rats, robots buying automata, homeostatically adjusted conformers and opportunists (or, bluntly speaking, into morons and zombies) can this great society follow its progress toward ever increasing gross national product.

Modern society provided a large-scale experiment in manipulative psychology. If its principles are correct, conditions of tension and stress should lead to increase of mental disorder. On the other hand, mental health should be improved when basic needs of food, shelter, personal security, and so forth, are satisfied.

World War II – a period of extreme physiological and psychological stress – did not produce an increase in neurotic or psychotic disorders, apart from direct shock effects such as combat neuroses. In contrast the affluent society produced an unprecedented number of mentally ill.

Precisely under conditions of reduction of tensions and gratification of biological needs, novel forms of mental disorders appeared as existential neurosis, malignant boredom, and retirement neurosis, i.e. forms of mental dysfunction originating not from repressed drives, from unfulfilled needs, or from stress, but from meaningless of life.

There is the suspicion that the recent increase in schizophrenia may be caused by the 'other-directedness' of man in modern society. And there is no doubt that in the field of character disorders, a new type of juvenile delinquency has appeared: crime not for want or passion, but for the fun of it, for 'getting a kick', and born from the emptiness of life.

Even rats seem to 'look' for problems, and the healthy child and adult are going far beyond the reduction of tensions or gratification of needs in innumerable activities that cannot be reduced to primary and secondary drives.

For similar reasons, complete relaxation of tensions as in sensory-deprivation experiments is not an ideal state but is apt to produce insufferable anxiety, hallucinations, and other psychosis-like symptoms. Prisoner's psychosis, or exacerbation of symptoms in the closed ward, and retirement and weekend neurosis are related clinical conditions attesting that the psychophysical organism needs an amount of tension and activity for healthy existence.