Evolution and Human Destiny

by

FRED KOHLER

PHILOSOPHICAL LIBRARY
New York

15 E. 40TH STREET, NEW YORK

PRINTED IN THE UNITED STATES OF AMERICA
BY HALLMARK-HUBNER PRESS, INC.

Acknowledgments

The translation of a set of ideas into a presentation understandable to others, requires nearly always the prodding as well as the help of other individuals.

In this connection I am greatly indebted for the encouragement and help that I have received from Dr. A. Barton, who has done much to cause this book to be written. Special credit is due to Mr. John La Marre who has made contributions during the later stages of the preparation of the manuscript and who insisted on an unwavering statement of the conclusions reached, overcoming my own emotional reluctance to do so.

After completion of the original manuscript I was fortunate to be introduced to Professor Paul Kosok. Professor Kosok who has worked along similar lines for many years was extremely generous in making the results of his own thinking known to me. Discussion with him caused me to make some significant clarifications in the book. From Mr. Robert Ullman I have received valuable help, especially on the first four chapters. For effective editorial assistance I am indebted to Mr. Elliot Gatner. Furthermore I would like to acknowledge the aid and encouragement received from A. Houser, Murray Klamkin, Professor Eugen Kullmann and Jerome Stanton.

Finally as the reader will find implicit in the thesis of this book, my own thinking of necessity operates within the stream of human thought of our times. In the selected bibliography at the end of this book, I have consequently attempted to include those works that have most influenced my thinking.

Table of Contents

EVOLUTION AND HUMAN DESTINY

Introduction

During the past century man's knowledge and understanding of the world about him has grown more rapidly than during any comparable period of his history. This increasing knowledge has permitted mankind to exercise a degree of control over environment never attainable prior to this time. Many of the limitations imposed by nature that were formerly believed insuperable, have been successfully overcome.

Man also has learned much about himself. His unity with other forms of life and his gradual ascent from simpler creatures has been established by evolutionary theory. Genetics has done much to explain the mechanism by means of which man and all other living things have evolved. The relatively new and groping science of Psychology has begun to account for the behavior of individuals. Sociology is attempting to gain understanding of the way in which larger groups behave. Anthropology, studying the habits of different cultures, especially the primitive ones, has provided new insight into the development of man that has occurred during pre-history and which is continuing right up to the present day.

The concept of the universe itself is undergoing drastic modification. Astronomy, aided by the powerful instruments that modern technology can provide and vitalized by the findings and concepts of modern Physics, has penetrated further into the unknown than the most optimistic predictions of only a few hundred years ago would have considered possible. The behavior and properties of matter and energy are being interrelated by Chemistry and Physics. The result of this is not only a better understanding, but also the spectacular advance of technology.

This new knowledge has been applied to living matter by the science of Biology which, only a century ago, had little in common with the other physical sciences. Based on the findings of the various branches of Biology, the processes occurring in living organisms are beginning to be better understood. This understanding has in turn stimulated the remarkable progress of medicine.

During this process of human learning, the progress made has actually resulted from the interaction of two distinct approaches. The more generally recognized of these is that of direct research in each specialized field of science. The less obvious but increasingly important process is that of abstracting the fundamental relationships between the basic findings in the various fields and integrating them into a unified, self-consistent body of knowledge. As the interrelationships thus established became known to the workers in their respective fields, new pathways were illuminated and fresh progress stimulated. There can be little doubt that synthesis of knowledge is as important a tool in man's intellectual workshop as the gathering of the facts.

Yet despite all the progress that has been made, the overall status of man's knowledge of himself, of the society he forms, his place in nature, as well as the relationship of life to other matter—is still rather unsatisfactory.

Is the development of life just an accident; or does it represent the result of an inherent process in nature? Are life processes completely explicable in terms of the physical and chemical processes that are known to apply for inanimate matter; or are some entirely new principles involved? Is the evolution of intelligent life, such as man, merely the result of an accident piled upon a series of accidents; or is it predictable in terms of a consistent pattern of development? How can the accomplishments of man, who in terms of his physical structure is not so very different from the other higher animals, be accounted for by evolutionary theory? What about consciousness; does not its very existence tend to contradict any assumptions as to the purely material nature of mind? Or is it possible for matter to become "self-conscious" under certain conditions; and if so, what are these conditions? Why must all living creatures die? Is this a result of the effects of the all-powerful Second Law of Thermodynamics which indicates that all naturally occurring processes must tend towards equilibrium and which on this basis predicts the eventual "death" of the universe itself? If death is indeed a consequence of this law, how then is it possible that life itself, although sacrificing the individual creature, has yet been able to persist for billions of years and has succeeded in developing forms becoming ever more complex?

It is true that science has not left these questions completely unanswered. Yet many of the answers given are none too convincing. They seem surrounded with a high degree of uncertainty. What appears most unsatisfactory is that some of the theories that would provide solutions have not been correlated with other established findings and consequently remain in a highly hypothetical stage. What also seems to be lacking is a unifying theory linking the concepts of the physical sciences with the mass of data that the social sciences are now accumulating and classifying.

There are other questions that man has been asking through the ages, which in the past have been in the realm of philosophy. They concern the problem of whether life has any purpose—and the relationship of man to the universe. To these questions science has as yet not provided answers and it is felt by many thinkers that the solutions of these problems are beyond human comprehension.

To this, many a scientist would reply that the very term "answer to these questions" implies a misunderstanding of the scope of science on part of the person posing the problem. He would quite rightly insist that science never provides ultimate answers but is satisfied to establish the existing relationships between phenomena and with adequately describing the observed data. Scientific truth then depends upon widest possible validity of the relationships established and upon their accuracy in predicting other phenomena which can be experimentally verified.

Still, the most proper appreciation of the nature of the scientific process does not obliterate the obstinate persistence of the human mind in grappling with the problem of the meaning of life. It therefore remains the task of science to include as much as is possible of the contents of this problem in the growing web of relationships and principles, which observation and inter-relation are knitting. All attempts in this direction must consequently first try to establish the broadest possible principles which would unify the total structure of human knowledge.

In the past few decades, this great need for synthesis has become more and more recognized. As the total volume of human knowledge is increasing at an ever faster pace, the difficulties confronting any human being desirous of keeping up with this broadening stream, are becoming tremendous. Yet, it is clear that all branches of knowledge are inter-related and that a proper understanding of these inter-relationships is essential for an adequate comprehension of the world we live in. It is indeed surprising, considering the unavoidable compartmentalization of the sciences, how much progress is yet being made. How this accelerating scientific advance is possible despite the limitations of the capacities of individual human beings, is one of the insights that will grow out of the material presented in this book.

What the author is attempting to accomplish in this treatise is therefore the following:

> "To synthesize certain presently known, but heretofore uncorrelated facts, phenomena and relationships into a self-consistent unifying structure."

The subject dealt with is the evolution of living matter in general and the development of man and human society in particular. In order to make the contents of this book accessible to as large a number of thinking men and women as is possible, only reasonably well established scientific findings and theories have been used.

While none of the individual conclusions growing out of this synthesis have been entirely unknown, they have in many cases been little more than speculative hypotheses, in competition with other ideas on the same subject and unrelated to one another. On the basis of the arguments presented by the proponents of these different ideas a scientifically valid choice can often not be made—and preference must frequently depend on purely aesthetic and emotional factors. It is because of the unifying overall presentation that the material in this book has the quality of a revolutionarily new and exciting idea. The previously apparently unrelated phenomena, when seen in their proper relationship, begin to take on a significance, novel in its implications. The reader will find, as the presentation unfolds, that the first group of problems mentioned in this introduction will gradually answer themselves, in a fashion that is internally consistent and where the implications raised by one solution become additional evidence for the validity of the other answers.

As for the problem pertaining to the meaning of life, no complete or certain solution should be expected. However, this presentation is able to generate a measure of rationally based hope, as to the eventual answer of these questions. The epilogue of this book closes with an idea, which although essentially speculative, is nevertheless arrived at by a reasonable extrapolation of the established concepts. The final vista permits human reason and understanding to penetrate into regions where mystical ideas have formerly held unchallenged sway. The implications of the concepts so developed might well provide the basis for an "universalist" outlook arrived at by means of a scientific approach.

The reader who is a "stickler" for quantitative data, as well as the strict adherent of formal logic, will find fault with the manner in which the material in this book is presented. Wide use is admittedly made of analogy in order to show the essential continuity of the evolutionary process as it takes place on its various levels. Use of analogy, while generally not permissible according to the rules of formal logic, however appears justified in this presentation. Without its use, there would be serious difficulties in the proper evaluation of the inter-relationships of the phenomena discussed. The important thing appears to be the establishment of a causal relationship which is due to inherent principle, and which welds the situations cited into a unified structure. Analogy, then, becomes an illustrative device rather than an element of proof in a formalistic presentation.

The evolution of intelligent life, which has barely begun with the emergence of man, can lead him towards a future in which his present degree of control over environment and his understanding of nature will look puny in retrospect. Yet whether the road of human development will lead steadily upward, or whether it will be interrupted by severe setbacks with all the attendant sufferings for mankind, depends not on any inevitable evolutionary process, but may well be determined by the actions of human beings in our time.

It is in our generation that this path of human development is leading along the edge of an intellectual and material abyss, which while it may not actually threaten extinction for the human species, would certainly undo many of the advances of the past few centuries. A proper appreciation by human society of the process that has led to its formation—and that is now responsible for its transformation—can guide it so that the abyss will be avoided.

The author recognizes that the concepts developed in this book are likely to have repercussions not only in the physical sciences, but even more so in social theory and action. The object of this treatise, however, is to establish a more unified concept of the evolutionary process. Discussion of the implications raised by the theory presented is therefore not within the scope of this work. The author plans to discuss these implications at some future date, but hopes that, in the meanwhile, the ideas presented in this book will serve to stimulate lively discussion not only as to their intrinsic acceptability, but also in regard to their social consequences.

CHAPTER I

Pre-Organic Evolution and the Problem of Organization of Matter.

According to the best estimates available today, living matter began to develop about one to two billion years ago from the then existing non-living material. It is not known whether this process has taken place only on the earth, or whether it has and is taking place in other portions of the universe. However, it is certain that the development of living matter on the earth has given rise to structures of ever increasing complexity.

The non-living material which existed on this planet, at the time at which the first structures that can properly be termed "living" developed, must have included some organic compounds of a high order of complexity. Without the prior existence of such organic compounds, the development of life would have to be explained in terms of metaphysical considerations. To do so, not only does not solve the problem, but worse than that, places a road block in the path of scientific investigation and leads human intelligence into a blind alley.

As the organic compounds that gave rise to living structures could not have existed at the time the earth began to solidify, they in turn must have developed from simpler substances. It is consequently apparent, that a "pre-organic" evolution of chemical complexity must have preceded the evolution of life. Therefore in order to gain a proper understanding of the path along which living material has developed, one would do well to begin the investigation of the evolution of non-living matter as early in the history of the universe as is possible.

There is, of course, no certainty of the specific manner in which the galaxies with their fantastically great number of individual stars were formed. However much available evidence leads to the view that the galaxies condensed out of the extremely rarefied gas or dust that at one time filled tremendous spaces, but was in unstable equilibrium because of internal gravitational forces or turbulence.

It is not necessary to discuss here whether this process is one that may be going on continuously somewhere in space, or whether it took place only during an earlier stage in the development of the universe. Nor need one agree fully with this particular theory of the formation of the galaxies; for in any event it is difficult to suppose a situation in which matter, existing prior to the formation of our galaxies, could have existed in a form of greater complexity before galaxy formation, than after the completion of this process. It therefore seems reasonable to state that the complexity of organization of matter in the universe must at one time have been of low order.

A somewhat different, but more concise, way of expressing this situation would be to state, that the *a priori* probability of a given quantity of matter existing in some form of low complexity of organization is greater than the probability of this same quantity of matter existing organized in some form of galactic system.

The discussion of *a priori* probabilities of the existence of systems may well seem unduly academic and beside the point in the first chapter of a discussion of evolutionary development. However the central problem of the development of living things is intimately tied up with these considerations. After all, life must be considered to represent matter organized into systems of great complexities. How such orderly aggregates could develop in the first place, persist and continue to become more complex, is not so easily explainable in terms of the generally accepted laws of the physical sciences.

One of the most fundamental maxims of the physical sciences is the trend towards greater randomness; the fact, that on the average, things will get into disorder rather than into order if left to themselves. This is essentially the statement that is embodied in the Second Law of Thermodynamics.

Now it is true that that overall development of life represents a trend in the opposite direction; namely, towards greater orderliness. The fact that the physiochemical processes that go on in living organisms are "Second Law Processes" and the realization that maintenance and expansion of life requires energy produced at the expense of decreased orderliness elsewhere, can of course be used as an argument in favor of the general applicability of the Second Law. Yet at best, while the development of life may not clearly contradict the trend towards randomness in nature (provided the Second Law is stated very broadly), the trend towards randomness can hardly be used as a basis on which the development of life could be predicted. In order to make discussion of the problem at all possible, a rather rigid definition of terminology as it will be used in this book is clearly essential. The author must therefore urge the reader to go through what may appear to be some difficult pages in the hope that the understanding that can consequently be gained further on in the book will prove to be sufficient reward.

ENTROPY AND "EXTROPY"

The concept of the probability of existence of any particular system of organization of matter is to some extent expressed by the term entropy as it is used in thermodynamics and physics. Yet the ready use of the concept of entropy, unless the manner in which it is employed is clearly defined, can easily lead to confusion, as the meaning of the term is not always the same. It is used in current literature to express two concepts which, although they are ultimately perhaps identical, nevertheless have their separate utilities.

In so-called classical thermodynamics entropy generally is a measure of the available energy of a given system under defined conditions, either in respect to its surroundings or in respect to itself. Here an equalization of the arrangement of matter, or energy within the system, generally referred to as degradation, is termed an increase of entropy. It is the difference between the entropies of states that is of importance. Knowledge of absolute entropy is not essential, and is generally lacking.

Degradation corresponds generally to an increase of randomness of the system. The more random the system, the greater the *a priori* probability of its existence as compared to the existence of some less random system.

However the original concept of entropy as measuring the degree of randomness has in some of its applications been expanded to a point where it bears very little apparent relationship to its original definition in terms of available energy. The manner in which the term entropy is used, for example, in cybernetics has transformed it fully into a concept that measures the probability of a system, rather than the energy levels. It is indeed difficult to understand the relation to available energy if one considers such a statement as "the entropy of a message" or "of a book" or "of a clock mechanism." Because of this situation, the author intends for use in this book, to re-define the term entropy to distinguish between the meaning that entropy has in classical thermodynamics and the concept of entropy used as a measure of randomness. To do so may appear unnecessary to some readers. The separation however, cannot do any harm, but will prevent confusion. From now on therefore, the term entropy as used in this text shall refer exclusively to the concept of randomness of a system.

As most of the material in this book will be concerned with orderly systems, a term expressing orderliness is more convenient to use than one dealing with randomness. Such a term can be found, by giving a name to the reciprocal of "entropy". We shall name this reciprocal "extropy."[1]

If one follows the evolutionary development of our

[1] The use of the term extropy has been suggested to the author by Professor Paul Kosok of Long Island University. The meaning of this term is quite similar to the "negentropy" referred to by Erwin Schroedinger in his book *What is Life?*

solar system from the view point of its change in entropy one finds that the total entropy of the entire system has increased. However, curiously enough, it appears that the entropy of certain portions of the matter constituting this system has been decreasing. As solidification of the crust of our planet took place, processes such as crystal formation became possible. The structural complexity of a crystalline solid is certainly greater than that of an equivalent quantity of liquefied matter. Now conditions over the surface of a planet such as the earth could not have been fully uniform. Different substances consequently accumulated at varying locations. This varying abundance of different materials must be expected to have given cause to further interactions between the then existing elements and compounds. Some of these interactions produced compounds of increased complexities with their correspondingly more intricate crystal structures. At spots where the crystals of such compounds formed, a very pronounced local increase of extropy can be postulated to have taken place. This local increase of extropy can be considered to have been especially great in such localities where the compounds forming and interacting, included those of the element carbon which, because of its atomic structure, tends to form compounds of great complexity.

CRYSTALS AND COLLOIDS

The formation of crystalline solids certainly constitutes an important step in the development of matter of higher extropy. In the crystal, the individual atoms are arranged in an orderly fashion very much different from the random distribution that exists in liquefied matter. It is of interest to consider that a crystal constitutes matter which has the ability to form more of its particular kind of structure if placed in proper surroundings. Such a proper environment, for example, is a super-saturated solution, which may therefore be regarded as a nutrient medium for the crystal. Consequently under proper conditions the crystal has the property of creating a local increase of extropy in the region of its immediate surroundings, which however is offset by an increase in the entropy of the less immediate surroundings. In other words it has the ability, under certain conditions, to reproduce its own structure.

The significance of these properties of crystals has been generally recognized and the analogy to some of the properties of living matter has been given ample consideration. Ordinary crystals should of course not be considered to be alive. They require the molecules or ions that constitute their substance in order to grow. Living matter on the other hand is able to rebuild its own very complex structures from substances simpler than its own configurations. Nevertheless the analogy is a useful one. It aids in the illustration of the essential continuity of the process of pre-organic evolution and the evolution of life.

Of greater complexity than crystals and consequently of greater extropy are colloidal substances, which are composed of an orderly array of atoms. They differ from the simpler crystals as a result of the much larger number of atoms that are required to constitute a unit of minimum size, which will show all the characteristics of the substance. Their complexity becomes particularly great when one considers those colloids which are made up of a large variety of structurally differentiated atoms. Under proper conditions colloids grow by adding suitable molecules from their immediate surroundings to their own structures in a somewhat similar, although far more complicated manner than that followed by the simpler crystals.

Proteins are colloids which are orderly aggregates of a very considerable number of the molecules of several amino acids. Proteins are substances of great complexity which may be regarded as constituting a rather high level of local extropy. It appears probable that the formation of proteins from amino acids was a process which did not happen all at once but required the prior formation of a chain of intermediate compounds of increasing complexity. Such a process should be thought of as having required a long period of gradually increasing complexity until substances with the complexity of proteins were formed.

CHAPTER II

The Most Primitive Forms of Life

THE VIRUS "RE-FORMS" ITS STRUCTURE

The Viruses are considered to be the most primitive forms of living matter known today. These viruses are essentially protein molecules with an unusually highly developed ability to synthesize their own structure from proper surroundings. Since amino acid polymers (proteins) are not extremely stable substances it is evident that, of the various intermediate precursors of protein-like molecules which may have developed on a chance basis during the course of time, only those possessing the property of re-forming their particular structure under the relatively widest latitude of conditions had a chance of persisting.

One encounters here at this very early stage of development of living matter the principal determinant of evolution, namely, probability of survival. Throughout this book, there will be discussions of just how this determinant has been responsible for the fact that some portions of matter have assumed ever more complex structures. These more complex structures are equivalent to a higher level of extropy. The process, as will be shown, appears to have been one of increasing complexity of individual packages of matter; the integration of these packages to form a new entity, then again a gradually increasing complexity of the new entity leading to a new integration on a higher level and continuing the process further in the same fashion.

The presently existing viruses, to which the most primitive, first "living" molecules may have been similar, do not possess the ability to synthesize their structure from a mixture of amino acids. This, however, is not surprising, as there are practically no such mixtures left in "native" form on the earth. Amino acids, unless synthesized by plants, are now only available in nature through the breakdown of living material. Consequently present day viruses are necessarily parasitic to such material.

It is interesting in this connection to note that the bifurcation of living matter into what were to become the animal and plant branches of life appears to have taken place early in evolutionary history. Initially of course living matter must have had the ability to synthesize its own structure from substances not derived from other life, since there was, by definition of "initially", not enough living matter available to provide raw materials for living forms. Only after some reasonable concentration of organisms had been established, could it have been possible for some of that living matter to draw on its living surroundings for material with which to build its structure. Plant life is remarkable for the further development of the originally necessary property of living matter to synthesize its structure from relatively simple compounds. Many plants even now do not depend upon compounds of intermediate complexity to build their substance, but are able to do so from very simple starting materials. In plants extropy is consequently locally increased at the expense of energy absorption from sunlight. The over-all effect is consequently in accord with the Second Law of Thermodynamics.

Animal life however depends upon the availability of comparatively complex substances, which being of a high extropy level cannot persist for long unless constantly replenished by synthesis from simpler substances. Plant life is consequently an indispensable prerequisite for the existence of animal life of the type familiar to us. This basic dependence of animal life upon the flourishing of plant life is ultimately predicated upon its inability to utilize simple compounds to build its own structure. This consideration is of greater fundamental significance than the well-recognized and more frequently discussed metabolic interchange that exists between the two branches of living matter.

The breaking down and utilization of complex materials for the building of biological structures makes a source of energy available to animal life which potentially can be useful for purposes other than the mere building of structure. Such energy can be used for motive power. The ability to make use of energy derived from decreasing of the complexity of other matter is of great importance in the development of animal life. It is interesting to note that as evolution gives rise to more complex creatures, the complexity of the necessary building materials which can no longer be synthesized and must consequently be obtained from other life, also increases.

At the present time not very much appears to be known about the transition from the essentially molecular viruses to cellular organisms. However, it is known that many grades of complexity exist among present day viruses. One of the simplest, the tobacco-mosaic, appears to be little else than a reproducing protein molecule. A complex one, like that of vaccinia, approaches the size of some cellular organisms and contains a variety of different substances. A group of organisms, known as rickettsiae, may be an intermediate form. They appear to be organisms which consist of more than one molecule, but are not yet integrated into a cellular pattern.

THE CELL A NEW ENTITY OF HIGHER ORGANIZATION

Of greater significance than the understanding of the actual mechanism by means of which the evolution of virus to cell may have taken place, is the realization that one deals here with an integration of initially clearly separate components forming a new entity. This integration process produces a further increase of the local extropy level. The association of complex molecular units, which makes cell formation possible, is somewhat analogous to the association of the relatively simpler molecules which form the more complex polymerized molecule on a lower level. This polymer formation is again in certain respects analogous, though of course not identical, to the association of atoms to form a molecule such as an amino acid occurring on a still lower level. Even the formation of atoms from sub-atomic particles fits, as a possibly initial term, into the evolutionary series of integration and increasing complexity of matter.

In each of these successive integrations, the resulting new entity is of higher extropy than its component parts arranged at random. The new entity is generally stable over a narrower range of ambient conditions. It shows entirely new properties, which could hardly be predicted from the properties of its individual component parts. Yet in its microstructure the constituent parts are preserved as recognizable sub-units. As the complexity of matter increases and its extropy consequently increases, the differential between the extropy level of the ambient (which is much lower) and that of the packages of high extropy, biological matter increases. As this differential becomes greater the problem of survival of the high extropy biological matter becomes more severe. Only those forms of high extropy matter which have the property of synthesizing their structure from their surroundings have a chance to persist.

For this reason, most of such highly complex material that is to exist for any cosmically significant length of time must necessarily show the characteristics of life.

The method by means of which such complex matter maintains its structure, perhaps more properly termed "the perpetuation of its high extropy status," certainly warrants some consideration.

In the crystal, more crystalline substance is formed in the proper medium by simple addition of the respective atoms or ions to the existing crystal structure. This addition is governed by inter-atomic forces, which result from the structure of the individual atoms. Chemistry speaks of valence and resonance forces. In colloids a similar though far more complex situation prevails. The mechanism of polymerization has also been found to depend upon valence and resonance forces. However the situation here is more difficult to analyze as one deals with a larger number of units as well as with secondary valence and resonance forces, which are not so readily related back to atomic structure.

In the virus the mechanism of perpetuation appears to be basically still that of the colloid. However a new element enters. This is the breaking up of the entire molecule into self-sufficient components after a certain amount of growth has taken place. This process is a form of subdivision and reminds one of the cellular method of reproduction by means of fission. In the unicellular organism one can for the first time properly use the term reproduction in its purely biological sense. Yet one is in reality not dealing with something that is so entirely new. "Re-production" of structure has been an essential phenomenon in relatively less complex matter, otherwise it could not have persisted. Now, merely the mechanism becomes far more intricate as indeed the structure to be reproduced has similarly become much more complex. It is interesting to note that in the one-celled organisms (protozoa), it is the entire organism that reproduces by fission, while the individual molecules comprising the cell perpetuate their status by essentially the same process followed in the virus stage, namely, by "template like" duplication of structure. It will be shown that, as one traces the evolutionary ascent of life further to the point where another integration of matter takes place, the method of reproduction of structure followed by the sub-units comprising the new entity, remains virtually unaffected.

Now while it is true that the general process of reproduction common to unicellular organisms is cell division, or as the biologist would call it, mitosis, a quite different process is occasionally found especially among the larger and relatively more complex protozoa. This process is the very opposite of fission. It is a form of cell fusion, the temporary joining of two cells for the purpose of inter-changing parts of their nuclei. The biologist terms this process conjugation.

This is indeed a surprising phenomenon. On first analysis it does not seem to accomplish what reproduction is supposed to do. It appears to contract rather than to expand the abundance of the species. Yet it is certainly a highly significant process, as it tends to reactivate and to prevent eventual enfeeblement of the individuals participating in the conjugation process. At the same time it seems to constitute a process antecedent to that of the germ cells of multicellular organisms. Investigation of the significance of this process reveals highly interesting data concerning the phenomenon of death in living matter. It also furnishes data about the significance of sexual reproduction in higher organisms.

In many ways the following chapter, which discusses these matters, stands separate from the rest of the book. If the argument advanced in the chapter should not prove acceptable to the reader, the main thesis of this presentation would still not be negated. Since the theory to be advanced in the next chapter appears quite logical and provides explanation where there has been none advanced elsewhere, the temptation to present it here cannot be resisted.

CHAPTER III

Biological Death and Sexual Reproduction

HOW CONJUGATION DEFEATS DECAY TOWARDS EQUILIBRIUM

In some of the more complex unicellular organisms, reproduction by cell division takes place for many generations, but after some period of time the daughter cells appear to lose vigor, growth and the rate of fission slows down. However, if at such a point, conjugation takes place between two such cells, the organisms are invogorated and become able to subdivide for many new generations.

Why, one may ask, does the attenuation of vigor take place in some unicellular organisms after a number of generations? Why can some species get along without it? Why does conjugation invogorate? Why does it seem to take place to a greater extent in the more complex unicellular organisms and usually become a necessity in the most complex forms? Why is a similar cell fusion process the mechanism used in the sexual reproduction of the more complex multicellular forms of life?

In order to attempt to find an answer to these questions one must first consider the effects of the surroundings upon life. As expressed by the famous Second Law of Thermodynamics, matter and energy in the universe generally tend toward greater randomness; that is, toward a state of greater probability. This means the entropy of the universe (at least in our region of space) is constantly increasing. Yet we have seen how, under various local conditions, some collections of matter may move in a direction of decreasing entropy and develop into ever more complex forms. This development however takes place in an environment which follows the Second Law. Consequently only those low entropy (high extropy) collections of matter which have the property of resisting the "ravages" of the Second Law have any chance of long survival. High extropy matter which therefore gradually acquires the properties which permit us to call it living material, presents a considerable differential between its own high degree of complexity and the relatively lower level of the ambient. The problem of the maintenance of the high extropy of such living matter consequently becomes a difficult one.

In the virus stage the most fundamental property of living matter, namely, in its ability to continue resynthesizing its own structure, solves the problem.

However during the process of synthesis errors will occasionally take place. Such errors must be expected to occur at random intervals. They are events caused by the occasional energetic particles which, in accordance with probability considerations, will at times appear at the prevailing temperature level. Errors will also result from such causes as incident radiation of sufficient quantum energy and from external chemical and physical agents. These "errors" generally lead to structures which either are unable to function, or are at least less effective than the original. These "error products" will consequently in time succumb to the action of the Second Law. Yet at times some of these "errors" can produce biological material of such a type of organization as can maintain and re-synthesize itself in a given environment more effectively than the original. Such an "error product" then becomes the ancestor of a new strain of living material. In organisms, such an error of synthesis is called by the biologist, a mutation.

Now this process is sufficiently effective in the virus, which is essentially only a single molecule, where a change in structure anywhere is a change in the nature of the *entire* individual. But in a cell one deals with a multitude of molecules. Any one of these is subject to random change by the very same agents that have been enumerated. Now one can see that here such a random change does not as much affect the *nature of the entire* individual, as it affects the *orderliness* of its internal organization.

What in effect takes place here is an error synthesis of somatic material—a somatic mutation. A similar process taking place in the germ cell of a multicellular organism gives rise to the more familiar genetic mutation. A little later we shall discuss the reason why the result of a genetic mutation is so different from that of a somatic mutation. At this point it is our object to consider the effects of the less spectacular somatic mutations. This distinction is of course somewhat difficult to apply to the unicellular organism where somatic and genetic effects are not yet clearly differentiated and where, as we shall see, the effect of a change in some molecules of the cell may be somatic as well as genetic.

In the cell the functions of the individual molecules that constitute it are to some extent those of specialization. This specialized nature of the various constituent molecules may be simply due to their position within the cell, or may actually be the result of structural and chemical differences among these molecules. Therefore, "chance produced" changes in individual molecules comprising the cell have a high probability of adversely affecting the internal order of the cell. Its entropy will increase and gradually as the damage accumulates, its ability to function properly will become impaired. This is precisely the effect that an environment of a much higher entropy level should have on a low entropy collection of material. Unless means become available to repair the damage, the cell will eventually be somatically mutated to the point where it can no longer function. When this happens the cell may be said to suffer natural death.

The number of molecules in any one cell mutated, as well as the number of particularly damaging mutations is, other factors being equal, a function of time. The age of a cell may then be said to correspond roughly to the amount of mutated material it contains which, at least statistically speaking, is a function of the time during which its unbroken lineage has existed. In this manner a fundamental relationship can be established between the passing of time and such physico-chemical processes in living material capable of affecting biological structure.

The simpler the structure of a cell, the smaller the degree of molecular specialization—the less damaging is the effect of any one mutation. The smaller its physical size, the lower is the probability of any one mutation occurring during a given length of time. As a result of all this, we find that simple cells can reproduce indefinitely by means of only a binary-fission process, (mitosis) as there will always exist cells which have escaped mutation prior to fission and some of whose offspring will likewise escape unharmed before their own division and so forth. Of course some material will be mutated in such a fashion as will result in eventual death. This, however, will not too adversely affect the survival of the species, as long as a sufficient portion of cells in each generation escapes. As the mutations in unicellular organisms (certainly if they occur in the cell nucleus) are transmitted to the fission products, they are simultaneously somatic as well as genetic mutations. They will therefore at times give rise to a successful new strain.

Now as has been discussed, the amount of damaged material carried by each generation is statistically proportional to the existence span of that generation. The seriousness of any damage done depends on the complexity of organization of the creature. Generally the more complex unicellular organisms (protozoa) have longer life spans than the simpler ones. Consequently an increasingly smaller portion of each generation survives without serious damage having been done, as unicellular creatures become larger and more complex. Therefore, unless an effective method were to develop, by means of which the mutation damage could be controlled, there would exist a definite limit to the complexity to which cells were able to develop and still survive as species.

The new method, that arose in the process of evolution to undo mutation damage, is conjugation! The manner in which it works can be explained in the following way.

It is certainly valid to assume that the probability of two cells chosen at random having identical mutation damage is rather low. By identical mutation damage is meant identical changes in corresponding molecules of the cell nuclei. It is also true that in many cases the mutated structure is chemically less stable than the original one. Now during conjugation there is a chance that the mutated molecule will be discarded altogether, or that the more stable of the two corresponding molecules, (which are now the genes of the biologist) usually the non-mutated one, will determine the structure of the cells after conjugation. In this fashion the effect of the somatic mutation is not transmitted further to the offspring and the resulting organisms are again able to give rise to many new generations, until the cumulative effects of somatic mutation again inhibit function.

The process of conjugation as it is discussed here, is of course an idealization of what actually does occur. Conjugation as it takes place in protozoa is a very complex phenomenon. However the essential features of the intricate process are the disintegration of part of the nuclear material of both cells and the fusion of the remaining material in such a fashion as to produce a union of the homologous members of the remaining nuclear material of each cell.

The reader who has some background in Biology will probably object at this point, because it is true that many protozoa (such as the amoeba) exhibit conjugation, but can also survive by means of binary-fission alone. Such a reader may also be thinking of the famous chicken heart tissue that was able to survive in a proper nutrient solution for a long time. However these objections do not invalidate the theory of eventual cell death by somatic mutations. It has been accounted for, that simple cells, as a species, can survive by fission alone. It is therefore not surprising that there should be cells of an intermediate complexity which can still get along by division only, but do at the same time already exhibit the mechanism of conjugation. It is through such intermediate forms that the most complex unicellular organisms must have developed. Most varieties of paramecium, for example, can no longer survive as species by fission alone. They are already sufficiently complex, for conjugation to have become a necessity, if the species is to continue.

The chicken heart tissue probably consists of cells which are relatively resistant to mutant damage. Therefore these cells can exist for many generations without showing a sufficient amount of damage to impair function. Also, as happens generally in the tissues of multicellular organisms, the seriously mutated cells fail to divide vigorously and die, while the undamaged ones become the parents of new generations of healthy offspring. If such were not the case, the life of the more complex multicellular organisms would be brief indeed. More than that, the potential life span of certain types of cells in the organism can probably be greater than the average life expectancy of the entire organism, which is likely to be more closely determined by its least resistant, rather than by its most resistant cells.

Death then, appears to be a result of the effects predictable on the basis of the Second Law of Thermodynamics upon the materials comprising living organisms. Cell fusion, or conjugation, therefore, seems to be the method by means of which a species of relatively greater complexity succeeds in preserving itself. For the individual of any such species, however, death is a thermodynamic necessity.

The mechanism of conjugation by means of which the somatic mutation damage is prevented from enfeebling the new generation is ingenious and amazingly effective. It is indeed difficult to contemplate another type of process which could in so successful a manner solve the problem of permitting living matter to escape thermodynamic annihilation.

For completeness, another method of rejuvenation which is found in certain protozoa should be mentioned here. This process is known as endomixis. In endomixis rearrangements or exchanges between the nuclei of the same cell take place. This internal process apparently re-establishes the cell-orderliness needed for proper function which has been adversely affected by somatic mutations. It may be regarded as a sort of internal conjugation. Certainly, the existence of this process does in no way invalidate the argument pursued in this chapter.

The bifurcation between the animal and plant branches of life occurred at an evolutionary stage below the development of more complex protozoa. It seems therefore highly probable that both branches of life independently evolved the cell fusion method of reproduction. It is equally significant that the inevitability of death for the individual, but the preservation of the species, holds equally for plants as well as for animals.

DEATH IN METAZOA

The method of reproduction found in the higher multicellular animals as well as in the higher plants depends clearly upon the mechanism of cell fusion. The cells that fuse of course are then no longer cells which act as both somatic and genetic cells at the same time, but are highly specialized genetic cells, the complex structure of which carries the code of organization of the entire individual. The situation will be considered again later when we shall discuss the nature of the multicellular organisms (metazoa).

In complex higher animals and plants, the cause of aging and natural death need of course not be the accumulated mutation damage in all the tissue. As has been pointed out, different types of cells vary in their resistance to mutation damage. So at the time a higher organism dies, the somatic mutation damage accumulated in most of the tissues of the organism may be quite low. However in higher organisms, the dependence of all the cells upon certain specialized organs is quite complete. Furthermore the rate of fission in cells and cell growth, which largely determines the extent to which mutation damage is kept under control, is dependent on various specialized organs, such as the glands that determine the general cell metabolism. Consequently mutation damage need only seriously affect certain, especially sensitive groups of cells, in order to start an accumulative degenerative process. This situation may account for the greatly varying life spans of the various species, as well as for the fact that the process of aging in the higher species is at first slow, but proceeds with much greater speed at the end of the natural life span.

The theory that natural death in metazoa is a result of the direct or indirect effects of somatic mutations has some bearing on the problem of cancer. Death from cancer, can of course not be considered natural death in the way in which one may regard death at very old age. However there is considerable evidence that cancer originates because some very specific mutations have taken place in some cells of the organism, (perhaps only in one cell). The mutations producing cancer are of a very special nature, altering function of the cell, rather than just producing disorganization within it. Also the phenomenon is at least initially local and not diffuse, as is aging. Consequently there is hope that cancer can eventually be controlled and cured. Really effective postponing of aging in individuals will depend on the development of techniques that will control the disorganizing effect of somatic mutation; but while a very considerable extension of the life span seems probable, individual death will still be unavoidable.

CHAPTER IV

Multicellular Organisms

THE CELL-COLONY AS AN INTERMEDIATE FORM

The development of multicellular organisms from the unicellular creatures marks the next integration towards greater complexity in the evolution of life. For a better appreciation of the nature of the development of the multicellular organisms, it is helpful to consider some of the forms of life which stand intermediate between one-celled creatures and the fully integrated multicelled organisms.

Such an intermediate form of life are the cell-colonies. The volvox is a rather typical example of such a colony. Here one is dealing with an association of cells which, while they do not yet constitute a clearly defined multicellular organism, are certainly something more than just a random aggregate of cells. The individual cells of such a colony, if cut loose from the main body, are at times able to exist by themselves, but more frequently die not very long after leaving the colony. They are often unable to undergo fission outside the colony, or if they do, are not able to invigorate themselves by means of conjugation.

The extropy of the colony must be considered to be greater than the extropy of the total aggregate number of cells comprising the colony arranged at random. This is obviously true, as the orderliness of the arrangement has been superimposed upon the initial order existing within the cells.

Reproduction of the cell colony can take place by means of internal fission. By this method "daughter colonies" develop inside the "parent colony" and are eventually "born" by disintegration or inversion of the parent. However as one might expect, reproduction by means of binary fission alone cannot continue indefinitely. A form of conjugation process must take place at various intervals. Significantly enough this conjugation does not take place between entire colonies, but only between specialized cells from inside the same colony (hermaphrodite method), or between specialized cells from different colonies (sexual method). It appears therefore, that these specialized cells carry within their organization not only the ability to perpetuate their own structure, but the cells which they develop into have the additional property of association, forming colonies in the same manner in which their ancestors did. This means that the reproductively active cells of cell-colonies carry within their organization the pattern of structure of the entire colony. This is an important new characteristic.

In the colony it is still a question of viewpoint as to which is to be regarded as the individual; the constituent cells, or the entire colony. In the true multicellular organism, (metazoa) however, the individual must certainly be recognized as the entire association of cells, which are now so closely integrated that they can no longer be regarded merely as associated individuals. Specialization and interdependence now have developed to such an extent that the cells of the organism are incapable of individual existence outside of the integrated entity. Asexual reproduction alone can no longer assure perpetuation, as complexity of structure has developed to such an extent as to make necessary a fusion method of lowering somatic mutation damage. But conjugation of entire organisms would be mechanically awkward, to say the least, especially in the more complex multicellular organisms. Consequently as foreshadowed by the practice of the cell colonies, and furthermore consistent with the increasing cellular specialization, certain cells of the organism are designated exclusively to serve to propagate the species by undergoing fusion with homologous cells of other organisms of the species. (Or sometimes of the same organism.)

Such cells, specially designated for this purpose, are known as the genetic cells. In these cells the protein molecules that constitute them have a very specialized function. They are the carriers of the code that governs the development of the new individual resulting from the fusion and subsequent fissions of such genetic cells. Little is known at the present time about the nature of the mechanism by means of which these protein molecules (genes) control the development of the new individual. Yet even without a knowledge of the mechanism, it is still possible to see that the existence of such a type of process is absolutely essential, if multicellular life is to survive.

As has been shown, some sort of cell conjugation or fusion must take place in the more complex creatures, if the cell material is to escape gradual impairment of function leading to death, not merely for the individual, but ultimately for the entire species. Now as fusion of entire organisms, or effective interchange of cell nuclei does not appear to be mechanically feasible in metazoa, the remaining alternative is fusion of specially designated cells, the structure of which is representative of that of the entire organism. Only in this manner can a new individual of the species be created which is inherently free from the somatic mutation damage of its parents.

At this point the question may arise in the reader's mind that, after all, the material of the genetic cells is as much subject to mutation as that of the somatic structure. This is of course true. However what matters is that the effect of mutations in genetic cells is of entirely different consequence than the effect of such action upon somatic material. In somatic material the effect of mutation is disorganization, and such disorganization spells eventual death to function. In genetic cells the internal organization does not exist primarily for the purpose of cell function, but represents a code which determines the makeup of the new individual. Consequently here mutation would result in a change of that code. Such a change is then not necessarily one towards disorganization, as the new code may represent merely a different pattern. The result of this changed code will be (if such a mutated cell becomes a parent cell) a new individual, having a pattern of cell integration which differs in some respect from that of the parent member of the species. The significance of these mutations on the development of life will be discussed later in this chapter. What is important at this point, is to realize that this process, while it will give rise to individuals of varying organization, will nevertheless permit such individuals to develop inherently free from the time-acquired somatic mutation damage of their parents. Of course genetic cells generally also "die a somatic death." However, there is no need to be concerned about the ones which age like all other organic material and become unfit without ever having fulfilled their function.

The cells that do in fact become parent cells are often those which are the most vigorous; that usually means the ones that have been least subject to mutation. Furthermore, very badly mutated genetic cells, even should they succeed in fusion, will generally result in an individual which would be so out of line, that development past the zygote stage does not take place.

Finally, germ cells when ready for fusion carry only one half of the nuclear material, (chromosomes) that is the standard equipment of somatic cells. These germ cells have prior to maturation undergone the process of "reduction-division" of nuclear material, termed meiosis. In this process, as has been discussed under the phenomenon of conjugation, there is a fusion of the homologous chromosomes of the cell. As a result of this fusion (which apparently also occurs on the "gene level"), the more stable, i.e. non-mutated genes, become the effective new genes of the haploid cells that are produced. Consequently genetic cells, at the time of their maturation, should be fairly free of the mutation damage done to their precursors. Of course this reduction of mutations that results from meiosis in the development of germ cells, does not apply to those mutations that the germ cells inherited from the past generation. Evidently these mutations, represent changes that are chemically more stable. In effect, all these processes combine not only to eliminate the effects of parental somatic damage in the offspring, but also to reduce the probability of structural changes in the offspring, that would result from mutations of the genes in the germ cells.

MULTICELLULAR LIFE, A SYSTEM ON A HIGHER LEVEL

Let us now consider the nature of the association of the cells that form multicellular organisms (metazoa). The system of organization of these cells is now far more integrated than it was in the cell colony. Existence of an individual cell away from the organism for any length of time has now become impossible. Specialization of cell structure has gone very much further now. There is no longer any question as to what constitutes the individual—the cells, or the integrated organization. The entire organism is now clearly recognizable as the entity and certainly functions as such. If one can at all speak of such a concept as the purpose of the organization, then it certainly appears that the multicellular organism does not function for the purpose of maintenance of the individual cell, but solely for the preservation of the organism as a whole. (Neither consciousness nor Teleology is implied here.) The cell colony developed initially because such an association in certain environments increased the survival probability of the individual cells. But in the far more integrated multicellular organism, the original "purpose" of the colony, to further the survival of cells as individual species, became ever more subordinated to the "purpose" of survival of the entire organism, both as an individual and even more so as a species of integrated entities. The total organism is not "concerned" about the fate of individual cells, except that of certain germ cells, and with these only because they are necessary for the continuation of the organism as a species.

Now if one examines this situation carefully, one will find that it is in many ways analogous, though of course not identical to the integration of protein molecules. These molecules developed through the "virus stage," and then became integrated forming an organic cell. Here too one deals with an integration of previously distinct units to form a new entity.

In just what manner the development of protozoa to metazoa took place during the evolutionary process is not certain. One possible such method would be via a cell colony of gradually tightening organization. A different path would result from partial mitosis. Such incomplete cell fission would first give rise to two celled animals, then four celled animals and so on. The path of fetal development followed by metazoa might be considered evidence that such incomplete mitosis was indeed also the way of evolution. However the fact that cell colonies are known to exist while we do not know of any two- four- or eight celled animals would indicate development via the cell colony as the more probable method. Finally there is no reason why both methods should not have taken place.

Considering the formation of multicellular organisms from an extropy point of view, it is apparent that the extropy of the integrated organism is greater than the extropy of a similar number of individually existing, non-integrated cells. The multicellular organism contains all the orderliness of the individual cell and in addition to that the highly orderly pattern of its own organization. During the life of the individual organism this high extropy level is preserved. By reproduction of the organism to continue the species, this level is preserved from one generation to the next.

The survival problem of the organism is one of the entire organism, not the survival of individual cells. Similarly in the cell itself, emphasis is on the preservation of the cell rather than preservation of the individual protein molecules that are the building blocks of the cell.

As multicellular organisms gradually developed from the most primitive to the more complex, the quality of the integration of the constituent cells improved greatly. This means that their ability to operate together and contribute their functions to the overall effectiveness of the entire organism became much greater. Some of the cells apparently became specialized for the specific function of aiding this very integration process. For example some cells developed into nerve material to serve for the transmission of stimuli from one portion of the organism to the next. Others grew to function as producers of special chemicals which serve as stimulatory or inhibitory agents affecting other groups of specialized cells. A few cells did as a matter of fact remain relatively unaltered from their original individual status. An example of this are the protozoa-like white blood corpuscles, which have the specific function of destroying such alien protozoan invaders as the organism may at times be plagued with. Still other cells became part of the digestive system—the circulatory system—were designated to carry compounds needed for the metabolism of all the cells, store food products, or became components of the increasingly complex reproductive system.

It is not surprising that such a process of development must have taken considerable time. Thousands of millions of generations of living creatures were born, reproduced and died during this process. The only driving force of the entire development that is presently known to us is the mutation of genetic material and the survival or rejection of these chance mutations. The determining factor in the survival of these mutations is their ability to function in relation to a given environment, especially in respect to their ability to give rise to a maximum number of surviving offspring. Mathematical analysis shows that even relatively small advantages of one mutant over the norm would, given a sufficiently large number of generations, account for a much greater abundance of the mutant individuals. The ever-changing environment on the earth's surface must have aided or hindered different mutants at various periods of time.

It should be noted at this point that while the integration and specialization of the cells follows a strictly rational pattern, governed by the requirements of the developing organism, there is no reason to believe that any conscious realization of this process existed in either the cells themselves or in the organism.

Yet the development of metazoa has on the average followed a very definite trend. This trend is the ever-increasing extropy of evolving organisms, together with the development of improved means of preserving this increasing extropy level.

What is the reason for this improving integration of the organisms and the increasing complexity of their structures? The usual answer that is presently available to this question is the well-accepted genetic answer, citing the selective effect of environment upon the naturally occurring mutations. But does an answer based upon these considerations only, really explain satisfactorily why evolution has moved generally in the direction of increasing complexity? Why indeed is there such a definite correlation between the increasing extropy of the developing forms of life and the passage of time? Is it not rather surprising that animal and plant evolution which bifurcated very early in the development of living matter should have taken a path which shows so many parallelisms? Does this not perhaps suggest that "complexification" may be as much one of the operating laws in the universe, governing matter under certain special conditions, as degradation is known to govern matter undergoing physico-chemical reactions? In fact, increasing complexity may be a phenomenon that could be mathematically derived from similar considerations as are used to establish the "Second Law" on the basis of statistical probability. (If the statistical group is extremely large and the time allowed great, the concept of a "probability of improbable situations" may have significance.)

While the question of how the cells were so "clever" as to integrate themselves so intelligently in the organism has frequently been asked (without serious expectation of any answer), one never hears of the query about the "clever" molecules that have formed cells, nor about the "clever" atoms that have formed molecules. Are these things really so completely different from one another, or are they perhaps just analogous integrations on succeeding levels, that can be accounted for on the basis of a general principle?

Genetic theory as it stands at the present time surely makes a great contribution in explaining the mechanism by means of which evolution has moved forward. Yet it is not quite satisfactory in accounting for the clear-cut direction in which the evolution of living matter has proceeded. We shall return to these questions later in our discussion, but the reader might do well to keep them in mind from this point on.

MULTICELLULAR ORGANISMS

As one follows the unfolding evolution of multicellular organisms, one finds that the increasing complexity of structure gives rise to ever more effective creatures. By the term "more effective" is meant creatures that have a better chance of survival in some particular environment than their "less effective" ancestors. To the statement that the more developed creatures are more effective (if defined as has been done here), an obvious objection may be raised. Namely that some of the lower forms of life can survive under conditions where the more complex organisms would perish. While this is certainly true, it does not really invalidate our premise. There are surely conditions where the higher forms of life have a better chance of survival than the lower forms. This must after all be true on a purely pragmatic basis—as they did in fact develop and survive. But what is the more surprising consideration, is the fact that they survived in spite of their higher extropy.

Based on purely thermodynamic considerations one would expect that generally high extropy formations have a smaller chance of preserving their level, than formations of a relatively lower entropy. This consideration is based on the assumption that the rate of equalization of entropy levels increases as the difference between these entropy levels increases. This consideration seems to hold for physical systems, the entropy of which can be quantitatively compared. Yet in examining living organisms one finds that low entropy forms do in fact succeed quite nicely in surviving. This appears on first glance contrary to thermodynamic predictions. Yet there is no necessity for lower entropy always to result in poorer ability to survive. It is only a probability. This means that occasionally there can be lowered entropy with an increased survival potential. Some low entropy forms can be quite stable.

A GENERALIZATION OF THE PROBLEM OF BIOLOGICAL SURVIVAL

Interestingly enough one arrives at about the same conclusion if one were to state the genetic argument of evolutionary development in the language of thermodynamics. It would then read something like the following:

> Whenever mutations of a structure take place, they take place in the directions of both increases and decreases of the complexity (orderliness) of the structure. Those changes that are in the direction of greater complexity involve a lowering of the entropy level. Generally this lowering of the entropy level will decrease the survival potential and consequently result in the vanishing of this particular form. However at times mutated forms will have their structure altered in such a fashion, that in addition to their lowered entropy they also possess a better, or at least adequate ability to survive. They in fact are the only forms of lowered entropy (increased extropy) that do survive.

What has been gained by so translating the genetic argument is that it has been made far more general. Recalling the essential equivalence of the random changes occurring in polymerizing colloids to the mutations in living material, the development of inanimate matter into more complex forms and finally into primitive living forms does now appear to be part of a consistent pattern. All this again points into the direction of the assumption that under certain environmental conditions, life is a consequence of the "complexification" of matter.

Whether this tendency of matter to "grow more complex" is actually subject to a law of nature which is in effect opposed to the law of degradation is a question on which there is considerable difference of opinion. Most physical scientists hold that the process of "complexification" is the additive result of low probability happenings which can (at least in theory) be accounted for on a mathematical basis. Many biologists on the other hand claim that the evolution of living things cannot be accounted for in this manner, and insist that a clear "building up" process exists in the universe.

CHAPTER V

The Societal Organism

Many multicellular organisms show a marked tendency to associate with one another. This trend becomes particularly noticeable once the organisms themselves have become fully integrated entities and reached a fair level of complexity. This banding together is a well-known pattern shown by many species. It is referred to as "sociability," "herd formation" and by other descriptive terms.

Specific examples of this trend towards association can be found in creatures all the way along the evolutionary ladder. Now, in most of these cases one deals merely with a loose association of individuals, which can hardly be described as a colony. However even the most loosely organized herd shows at least some pattern of organization. As the herd becomes more tightly organized, which evidently has happened in many species, the pattern of its organization assumes a very clearly recognizable characteristic, which is repeated from one generation to the next.

In cases where such a herd has become unusually closely knit, it is more in accord with the facts of the situation to regard the aggregate individuals no longer as just comprising a herd, but as actually forming a colony.

Over a great number of generations some of these colonies will become more integrated, as there surely will at times exist environmental situations which will favor the survival of more closely integrated colonies. Such a colony will therefore take on more and more the aspect of an entity with an existence of its own. The chances of survival of the individual member outside of such a colony will become increasingly smaller. Specialization of function of individuals to serve the collective needs of the colony becomes evident as the integration process makes headway.

Continuation of this process must be expected to eventually result in a colony so closely integrated, that one can no longer regard it as a mere colony. It will have developed an organic entity to such an extent that it must properly be regarded as an organism in its own right: that is, as an entity comprised of an orderly aggregate of multicellular organisms as the components.

This new entity certainly deserves a name of its own. It shall be called for the purposes of this presentation a SOCIETAL ORGANISM.

The next few pages of this book will be devoted to an examination of the various colonies of multicellular animals that are known to exist and to consideration of the extent to which the evolution of societal organisms is already under way.

INSECT COLONIES ILLUSTRATE THE PROCESS

The colonies formed by certain insects will be the first example to be considered. Nearly everyone knows something about the bees, the ants and the termites. Indeed the concept of an "ant state," or "bee state" has been suggested by many observers. Therefore the view regarding these colonies, as evolving organisms, may be regarded by the reader as presenting nothing new, except perhaps a somewhat altered terminology. Yet what this treatise is most concerned with is not so much the presentation of new facts, as it is with viewing these facts in their proper perspective.

The manner in which insect colonies function collectively has always been a source of wonder—and lack of real understanding. Without probing into the actual mechanism, some light may be thrown on the problem of effective functioning of insect colonies, by the realization that one is evidently dealing with a similar "mystery" as the one that surrounds the question; "why do cells act in coordinated fashion in multicellular organisms?"

One aspect that strikes the observer as especially remarkable about the insect colonies is their apparent intelligence. In its functioning the colony is acting as if it "knew" what it was doing. This appears particularly remarkable when one considers that the individual insect does apparently not possess by itself the degree of intelligence evident in the functioning of the colony, nor is there reason to believe that the individual insect is at all aware of the total organization of the colony, nor its own function in it. Experimental studies of individual insects surely seem to confirm this view. Non-colony-forming metazoa of a similar level of complexity do not show anywhere near the same degree of "intelligence" as does the colony.

Yet despite the apparent lack of consciousness of the individual insect, the colony shows a rational behavior; a behavior that is directed so as to assure survival of the colony. How is such a situation possible?

The answer that is usually given to this question is that the individual insects follow instinct, which guides them in such a fashion as to make orderly function of the colony possible. But just what is this instinct? One possible definition of instinctive behavior, which seems to cover the situation fairly well, is the following: "Instinctive behavior is behavior which follows a definite, predictable pattern, the function of which the organism behaving in such fashion need not be aware." Instinct generally serves the survival needs of the species, although at times when the environment has changed, it may actually harm survival, as instinct is not quickly adaptable. In the long run, however, only "survival positive" instincts persist, as creatures developing negative ones would tend to die out.

As true instincts are neither taught nor transmitted by example from one generation to the next, they must, as there is no other possibility, be part of the genetic code determining the species. Consequently one would expect them to be subject to mutation just as much as are the physical characteristics of the organism. Is there indeed any other way consistent with genetic theory, of explaining the development of instincts and their adaptations to various environments? Part of the very basis of the genetic determination of a species consists of fixing pattern and behavior of the individual cells forming the multicellular organism. It is the function of these cells in the organism and the pattern of their integration that constitutes an essential part of the information carried by the genes of the parent cells. Can one therefore state that the cells are following instinct? It appears that such a statement would have the same validity as one claiming that the ants in their colony are acting according to their genetic code. We are very likely dealing with analogous phenomena, but occurring on different levels.

Certainly, there is no individual cellular awareness within the multicellular organism. As a matter of fact there is no reason whatever for believing that individual cells possess any awareness at all. Yet the total organism functions effectively. The extent of awareness of the entire organism itself is a matter of degree. Awareness probably came into existence gradually and almost imperceptibly somewhere during the evolutionary ascent of animal life. A rigid definition of awareness is an exercise in semantics and would be of little use at this point. What matters is to realize that awareness (or if awareness in animals is denied, the tendencies leading toward awareness) increases, as the complexity of the living organisms increases.[1]

It is an interesting sidelight to note that there seems to be a far greater psychological barrier to surmount in accepting the fully unaware cooperation of insects in a functioning colony, than to admit the complete unawareness of cells in the multicellular organism. Could this reluctance be due to the fact that we believe that human society functions only because of the awareness of individual human beings as to their roles, and that therefore we find it difficult to see how any other colony-forming creature can act in so unaware a fashion? It will be discussed in the next chapter how the function of human society in many aspects is not necessarily determined by awareness of individual human beings, but may well be a far more unconscious process, at least from the standpoint of the individual

[1] This treatise makes a distinction between awareness and consciousness which will be discussed later in the book, where the manner in which these terms are used by the author will be clarified.

person, than one may care to admit. But before entering into that discourse, some of the features of colony formation among creatures other than man, must be discussed.

On the lower levels, where integration of complexifying units of matter takes place, some knowledge of the forces bringing about this integration exists. As has been discussed on preceding pages, these forces are valence and resonance forces determined by atomic and molecular structures. The action of these forces is most clearly seen in the case of crystal structure; less apparent but still yielding to analysis in the case of colloid formation. In the especially complex protein polymers with their unusually highly developed ability to re-synthesize their own structure, the pertinent role of recognizable molecular forces becomes obscure. That is the present situation on the "virus level." On the next higher level of integration leading to the development of living cells, nothing is presently known about the existence of physico-chemical forces producing the integration. Yet on the still higher level of the colony formation of cells (which may have given rise to the multicellular organism), something about the factors leading toward the integration is again known. However on this level structural complexity has already become so great that description of the integrating forces in terms of chemical reactions is not possible within the limitations of present knowledge. It is easier to see how these forces act, in terms of the over-all needs of the participating units. One now can consider these forces in terms of the problem of survival of the individual cells, which is being more satisfactorily solved by the colony. As has been shown, continuing integration of these colonies leads to the formation of integral metazoa.

It is probable that there is a continuity of the mechanism leading towards integration, which could be followed through the various levels of increasing complexity of matter, if only enough data were available. This lack of data is especially pronounced in regard to the integration of the virus-like protein molecules that must have been responsible for cell formation. There seems reason to hope that research into this phenomenon will make it possible to provide explanation in terms of chemical forces, as well as in terms of survival problems of the participating components. Once this is accomplished, the operation of the integrative process on various levels of complexity will become more understandable in terms of its mechanism. However as yet this cannot be demonstrated in the light of presently available knowledge. Therefore we shall not dwell on further discussion of this mechanism. Instead another significant aspect of the pattern of integration operative in evolution shall be considered.

This aspect may be roughly identified by stating that the product of the integration always comprises an entity that is more than merely the summation of its parts. Or expressing this in a terminology that can be related to thermodynamics one may state as follows: "The product of the integration has a higher extropy than the sum of the components of the integrated entity would have in non-integrated form."

This generalization certainly holds true for the colonies formed by multicellular organisms. Here specifically the orderliness of pattern of the colony itself, exists in addition to the orderliness of structure of the individuals comprising the colony. It is consequently evident that colony formation leading to the development of societal organisms is consistent in direction with prior evolution in its raising of the extropy level.

The available evidence indicates, that societal integration need not be a conscious process in its initial stages. In the colonies formed by insects the individual need not be aware of the total function of the colony in order to contribute to this function. Development of colonies initially comes about because under certain environmental conditions it serves to increase the chances of survival of the individual, or in a broader sense the chances of survival of the species. Yet as this development conditioned by environmentally imposed factors proceeds, the colony as an entity becomes more important than the colony as a mere mutual aid association of individuals.

Colony formation of multicellular creatures, leading in the direction of the societal organism is in certain respects analogous to the integrations that occur on various lower levels of the development of matter. However when it occurs on a higher level it results in new, emergent features. In all these integrations the extropy of the material involved is raised.

Integrations of complexifying matter are always most closely analogous to the nearest integrations both up and down the line, rather than to integrations one or more steps further removed.

THE SOCIETAL ORGANISM RAISES THE ORGANIZATION OF ITS IMMEDIATE SURROUNDINGS

Insect colonies have certain effects upon their surroundings. These effects result in an increase of the extropy level of the immediate environment. The full significance and reasons for this phenomenon will be discussed in the next chapter, but a few examples pertinent to insect colonies will be cited now.

The ground constituting an ant heap certainly is more orderly and consequently has a higher extropy, than the same ground would have if the ant colony were not present. The honey containers of the bees, constructed with mathematical perfection, surely have a greater extropy than the same amount of wax and honey in dispersed form.

The very fact that the insect colonies tend to arrange inanimate matter in orderly fashion, for some functional purpose, is certainly good reason to suspect that this process may be intimately connected with the existence problems of the colony.

On purely theoretical grounds, that is by extrapolation from evolutionary pattern, one would expect a colony, once it approaches the degree of integration that would justify its being termed a societal organism, to develop a reproductive system characteristic of an organic entity.

Among the insect colonies, features of the reproductive process emerge which are strongly suggestive of such a development. It is among the bees and related species that the reproductive process has gone the furthest in the direction of a societal method of reproduction. Here all the eggs developing into new bees are produced by just one specially equipped female. This female is fertilized by only one male bee, that is selected by an eliminative process somewhat reminiscent of the elimination of male sperm in female mammals prior to fertilization.

Other members of the colony have developed their own specialties, but at the expense of their reproductive faculties. The rather special process of reproduction of these insects is effective in preserving the established pattern of the colony, for as the colony becomes more and more of an entity, the biological purpose of reproduction appears to be more one of preservation of the colony rather than merely the reproduction of generations of individuals. The degree of integration and specialization that has been attained by certain insect colonies is so great, that survival of the individual animal outside of the colony is no longer possible. Even if individuals could survive for some time, a small number of loosely associated individuals could not reproduce themselves effectively. In such cases, the term "colony" is no longer descriptive of the existing situation. Behavior is more readily understood if one realizes that one is dealing with primitive forms of societal organisms.

What are the factors that are likely to determine the effectiveness of a developing societal organism? It is reasonable to expect that these factors should be analogous to those, that on a lower level would determine the effectiveness of an ordinary multicellular organism. On this basis, the following factors can be cited: Initial complexity of building units; total number of units participating in the integration process; degree of integration that has been achieved; degree of specialization of various groups of participating units.

Consideration of these factors indicates that the societal organisms into which such creatures as insects are capable of developing, will be clearly limited as to their maximum attainable effectiveness. The main reason for this is the relatively low initial level of complexity of the individual insects. On the other hand one can expect that the higher forms of animal life, which are initially far more developed than the insects, will, in the event of colony formation, ultimately give rise to far more effective societal organisms than those that can develop directly from the lower forms of life.

COLONIES OF THE HIGHER ANIMALS

As shall be discussed in the next chapter, colony formation among the higher animals has proceeded further in man than in any other creature. However it would indeed be surprising if this process were observable in man alone and not among any of the other species of vertebrates.

The initial phases of colony formation are certainly observable in the herds formed by many mammals. Similar associations exist among many species of fish, as well as among numerous kinds of birds. There are probably very few of the higher animals that do not show some associative tendencies. The rudimentary pattern certainly exists although the process itself may not have proceeded very far. However colonies are not formed overnight. Loose association must necessarily precede the tighter one.

The considerations of this book concern themselves primarily with pattern rather than with mechanism. Nevertheless it should be of considerable interest to analyze some of the specific factors that would tend to favor colony formation among the higher animals.

Perhaps the most important of these factors is imposed as a result of the sexual method of reproduction. Non-social existence makes it more difficult to find a mate and consequently will in certain environments have an adverse effect upon the survival of the species. Among the mammals, young animals are quite helpless right after birth and the offspring-bearing females are relatively more exposed to external enemies. Development of some forms of mutual aid will therefore be in the interest of assuring the continuation of the species. The animals of small physical size find association a form of protection against their larger and fiercer enemies. It is indeed among the species lacking natural offensive weapons, that colony formation appears to have developed to the greatest extent (ruminants, swallows, seals, monkeys) . Difficulties of environment are another reason militating in the direction of closer association.

A noteworthy example of the environmental factor are the penguins. Among these animals colony formation has proceeded further than among any other species of birds. Isolation of these creatures in a difficult environment evidently placed a high premium on cooperation.

Among the mammals other than man, colony formation has probably gone furthest among the beavers. Here one sees an example of the functional modification of the surroundings in the direction of increased orderliness. This is the kind of modification that has been found to be so characteristic of certain insect colonies.

Association and subsequent colony formation can be accounted for on the basis of genetic theory. This theory would claim that certain individuals due to mutant changes of their genetic pattern showed tendencies towards cooperation and association with other creatures of their own species. In certain environments the ones that showed this tendency must have had a better chance of survival than the ones that did not cooperate. On this basis the genetic pattern gradually became transformed to produce individuals with associative tendencies. In time this altered genetic structure became the characteristic makeup of the species.

But while the tendency to associate is apparently predetermined by the genetic code of the individual, the total pattern which this association assumes is not implicit in the organic makeup of the individual animals. A few individual insects, separated from the colony very early during their life spans, will show the apparent drives or "instincts" of creatures of the original colony, but are by themselves not able to fully reconstruct a functioning colony. Beavers raised away from the colony from babyhood on, will show the "instinct" of building dams, but will fail to perform this function with the degree of skill that would have been attained had they been raised in the colony.

It seems, therefore, that a new determinant has been introduced into the pattern of development of living matter. The colony does not perpetuate itself merely because of the biological constitution of the individual multicellular organisms with their characteristic associative tendencies, but association between generations is usually essential for the perpetuation of the colony. In this fashion learning from the older generation is transmitted to the younger one. It can therefore be stated that the heredity of a colony contains elements other than just the aggregate of the genetic patterns of the individuals constituting the colony. The heredity of a colony properly includes the historically established behavior of the colony. This feature is present to only the very slightest extent in non-colony-forming animals. The full significance of this process will become far more apparent in the discussion of the following chapter, which will deal with the colony formation of man.

The importance of this "social heredity" increases in relation to the genetic heredity of the individuals, as the integration of the colony proceeds in the direction of transformation into a Societal Organism. As a result such an organism must develop new "reproductive" traits operating on the societal level to assure perpetuation of its organic entity.

CHAPTER VI

Characteristics of Human Colony Formation

The one species in which colony formation has proceeded much further than among any other mammal is man. In fact some of the developments that have taken place in human society mark the initial phases that one would expect to occur during the beginning of the evolution of a societal organism. Now of course the viewpoint which regards society as an organism is not really new and analogies to this effect have been cited. The communications system of society has been compared to the nervous system of a living organism; the police to white blood corpuscles. Other comparisons of a similar nature could be enumerated. Even such concepts as group consciousness have found their way into recent literature. Some of the very terminology of our language indicates that there may have been an awareness (perhaps not fully conscious) of this situation for a considerable length of time. Yet the situation is not just figuratively so, but is rapidly becoming true in a biologically significant manner. It is only upon recognition of human society as a development consistent with the established pattern of evolution, that its nature can be understood and its future charted.

We think of human society customarily as an association of individuals rather than as a more or less integrated entity. If society were indeed nothing more than an association, its total characteristics should not differ greatly from the weighted summation of the characteristics of the individuals composing it. Yet there are many considerations showing that man is human in the fullest sense of the word only, because of the characteristics that he has gained as a result of such integration as has already taken place. Let us then for the moment consider the probable history of human colony formation, as based on findings developed from anthropological and sociological studies, as well as examine it from the point of view of the underlying thermodynamic-biological considerations.

THE IMPORTANCE OF LANGUAGE

Today there is little doubt that some several million years ago the ancestors of present-day man consisted of one or several species of primates. While some of the details of the physical and even more so of the mental makeup of these ancestors is not known, there is no reason for us to believe that they differed in any drastic fashion from the other then existing primates. Nor is it likely that they were so very much different from the presently existing primates other than man. They probably traveled in fairly large groups, assuring better protection for themselves and making it easier to find a mate and to raise offspring. This was almost certainly an unconscious process, yet much in accord with the to-be-expected pattern of association. Some mutual sound signals, such as are known to exist among other species of the higher animals, were probably in use among these ancestors of present-day man. Such signals must have been used to warn the group about the approach of dangerous enemies; to signal to a potential mate and to give expression to states of anger, pleasure, pain, and so forth. Whether language originally grew from these signals, or whether, as some philologists hold, symbol formation growing out of rhythmic noises and dances played the predominant part, we do not know for certain. But whichever the case may be, it does not alter the fact that the development of language played an essential part in the development of man as he exists today.

Now it is known that the other primates cannot be taught language to any appreciable extent. Therefore language in man must be more than merely the result of imitative learning of the individual. It must also have an organic basis. Without the necessary organs and nervous equipment no animal can master language. So, if one speaks of the instinct for language in man, all one is really saying is, that the ability to learn language constitutes part of his genetically determined makeup. If (there are a few cases on record) a child grows up wild, or is brought up by animals, no real language develops. Children who are brought up in a group, but hardly ever come in contact with human language, develop out of their babbling only the most primitive kind of vocal communication. On the other hand, animals brought up among human beings develop no language whatsoever.

From these considerations it must be concluded that the *ability* to master language is *rooted in man's biological structure,* but that language *itself* is socially acquired. The existence of the proper organic and nervous equipment is consequently a necessary but not a sufficient condition. Language must also be learned. This dual *individually-biological* and *social* root of language throws some light along the path of development which apparently is taken during the period of formation of a societal organism, such as human society is in the process of developing into. Here, instead of external environment alone acting as the survival-determining selector of genetic mutations, the internal environment becomes increasingly important as the selector. To explain just how this may have worked with language, one may reason in the following fashion: In a herd which depends to a considerable extent upon mutual signals, a mutant change in any one individual of the herd, permitting better signaling and better response to signals would favor the probability of survival of such an individual. This being true, such a mutant change will gradually become one of the characteristics of the species. On the basis of many such mutant changes the gradual acquisition by man of the necessary nervous and organic equipment for language can be explained. A similar argument can be employed to explain the development of man's highly developed central nervous system. (Also the use of his hands.)

But as has been discussed, biological makeup is not the sole key to man's language. Neither is his more highly developed nervous system by itself sufficient to account adequately for human achievement. When the ratio of brain development in man, to that in the higher animals, is compared with corresponding ratio of their mental achievements, one finds that man's accomplishments seem vastly out of proportion. How then is one to explain that man's ability is so very much greater than what one would expect on the basis of his brain development alone, basing the comparison on animal standards?

When the nature of man's evident ability is analyzed, one can hardly fail to recognize that much of it is based on learning in its broadest sense. Now it is true of course that animals also learn. But their learning takes place in a far more limited manner. Animal learning is based upon observation by the individual animal and the trial and error response to such observation. It is not based on any appreciable interchange of information with other members of the species. After all methods for such an interchange do not exist for them. Man, however, is able to learn through communication with other members of his species. He consequently avails himself of the experiences of other individuals, who in turn were and are able to increase their own effective range of experiences in the same fashion. This process does not hold true only within one generation, but also takes place from one generation to the next. This is of very great moment, for it means that the experiences of one generation can be directly transmitted to the next. This constitutes a new and unprecedented factor in the development of life. The extent to which such a transmission of experiences takes place among animals is by comparison very small indeed. At the very best, aside from man, the species only learns because those individuals who do not, fail to survive. Even then, the process is driven forward only by chance mutations and is consequently a comparatively slow one.

The entirely new method of learning that is consequently available to man as a result of the development of language, increases the effective experience of each individual, to an extent greater by an order of magnitude over that possible for relatively non-social animals. More than that, this experience is not strictly speaking individual experience. It is rather the experience of many other members of the species, existing now and extending back over many generations. One might say that much of the apparent intelligence of man is not his own individual intelligence, but is a manifestation of the intelligence of the developing societal organism. This realization does in no way imply that the minds of individual human beings are not repositories of this societal knowledge. Nor does it deny the very real contributions made by individual human beings to the growing record of human achievement. However, it is well to keep in mind that all such individuals made their contributions largely because they functioned within the total stream of accumulated human experience of their time. No individual genius, no matter how great, could possibly have designed a functioning television receiver either in the year 1000, nor in the year 1800 for that matter. The societal knowledge then available simply did not suffice. While it is of course true that the total knowledge of society is carried forward by individual contributions, it must nevertheless be recognized that compared to the total volume of human knowledge existing at any one period, the quantitative effect of even a greatly contributing individual must of necessity be small. While there is no doubt that our genius of 100 years ago could not have designed a functioning television set, his successfully constructing one, is even further out of the question. There exists no individual today, expert though he might be, who, given all the basic raw materials (various metallic ores, all needed chemicals, etc.) and permitted to use simple hand tools, (such as were available in 1800) could during his lifetime, construct this television set by himself. Even a very bright technician, engineer or physicist, probably does not have in his own mind sufficient knowledge of all the techniques that would be required, let alone the physical capacity for performing them. Yet television sets as well as numerous other equally complex items are being turned out by industry in tremendous quantities.

But it is not merely our astounding scientific and technical achievements, but indeed our most typically human characteristics that are essentially attributes of the social organism, rather than part of the biological pattern of the individual. Many of the human characteristics that are generally referred to as "human nature" fall into this category. They are in their present form because there exists now, and has existed for many thousands of years, a society which as a group was able to transmit information. An interesting confirmation of the societal origin of much of human nature is to be found in the histories of the few known cases of human beings who have been raised without any contact with other human beings. Such upbringing generally resulted in creatures, the behavior of which differed only little from that of the higher animals, and which showed few of the characteristics regarded as most typically human.

The importance of language in facilitating the growing integration of the human colony can hardly be overemphasized. It is probable that the circumstance of the dawning of language in man was an extremely important factor responsible for making him what he is today.

Verbal communication alone has its limitations. The number of other ears which any one person can reach are of necessity limited. Accuracy of transmission is not very high, especially over long periods of time. The degree of complexity of information that can be verbally transmitted is also inherently limited. As language itself is largely symbolic, it is not surprising that the first attempts to create visual language should also have been symbolic. These attempts probably date back to approximately that period in pre-history at which language itself reached a fair level of expressiveness. The development of writing meant that the power of language became greatly enhanced. Therefore, the ability to "remember" from one generation to the next likewise changed from a rather hazy and inaccurate process to one of considerable accuracy. Known history of human society cannot extend much further back than the period during which the art of writing first came into use. Certainly with the advent of writing, the rate at which human knowledge and technique advanced became very much faster than it had been prior to that time.

Now it is true that closer integration of a developing societal organism would be greatly furthered by improved means of communicating experiences and of remembering them. Consequently it is apparent that the knowledge of writing greatly speeded the integration process and may actually be regarded as the initial phase of the development of what might well be called a "societal memory." The invention of printing is again a step forward in the effectiveness of language. It means that the "societal memory" can improve more rapidly, become capable of greater accuracy and be partially shared by a greatly increased number of individuals. It is significant that the advent of the relatively wide use of the printing press coincides closely with a further increase in the rate of human progress. Significantly, the rise of ancient science also coincides closely with the perfecting of writing. The birth of modern science falls in the period just after printing came into use in the western world. Use of the printing press marks in effect a distinct improvement of the mechanism of the "societal memory." If one considers such a collection of information as is represented in a comprehensive set of encyclopedias, one can hardly fail to regard this as anything else but a deposition of societal knowledge. A deposition of this kind is not, nor could it be, the result of the experiences of any single individual. It represents a totality of society's accumulated experiences, reaching way back, not merely in an additive sense, but constituting in many respects an integration of these experiences.

It is understandable that the growing societal knowledge together with the improving "societal memory" should foster its own self-growth. In its initial phases when spoken language was the only available means of communication and when the spoken word alone served as the vehicle of memory, the rate at which human knowledge accumulated was necessarily a slow process. This must be particularly true, as the development of language sufficiently expressive for the transmission of more than the most simple ideas was itself probably a relatively slow process. It apparently took much longer than the total period of time that has elapsed since the dawn of known history. As writing came into use, the rate of accumulation of human knowledge certainly increased. A further marked increase of this rate takes place with the advent of the printing press, becoming ever more rapid, as an increasing portion of each generation could be effectively reached by this accumulating information. This last factor is a result of the increasing percentage of literacy among the human race, which has tended to increase on the average since the beginning of the art of writing. It is against this background of accumulating knowledge and its wider availability that the fantastic growth of science and technology became possible. This latter growth of course is equally based on the progressive accumulation of ever more effective tools, which interwoven with the increasing know-how, gives rise to machines which, outside of their obviously utilitarian purpose, also make possible the building of even better machines. Science, a result of accumulating human knowledge, is equally a causating factor of the further development of this knowledge. It makes possible a new specificity of direction, a new method of critical evaluation, and provides for much better indexing of the acquired information.

The advances of technology began about a century ago to free an increasing portion of the human race from the primary tasks of providing food and shelter. Consequently they became available for other functions, such as the production of more tools; the direct or indirect furthering of the growth of knowledge; the production of goods not immediately essential for the survival of individuals; or some form of activity in the mechanism of the social integration process. The increasing percentage of individuals so engaged contributes greatly to the rate of material progress. The great numerical increase of the earth's population, up to a point, is also both cause and effect of this material progress. All these factors combine to result in the exponential increase of man's effectiveness which certainly has taken place during the past few centuries.

However as shall soon be discussed, the implications of this material and scientific advance reach far beyond the obvious and are of the greatest significance when examined from the over-all point of view of tracing the development of the human societal organism.

In the human colony specialization of individuals is taking place to an increasingly noticeable extent. Society today is becoming ever more dependent upon the specialized skills of many groups. At the present time it is certainly no longer possible for any one individual to be proficient at all the skills that are now essential for the continued functioning of organized society. Various groups of specialists certainly differ to a marked degree in their average mental characteristics. In extreme cases they may even show differences of physical characteristics which are statistically measurable and significant. As an example, one would expect lumberjacks and chemists, when considered as groups, to show such physical differences. The extent to which specialization has proceeded is greater in the more advanced cultures than in the more backward ones. In modern civilization specialization is fostered more and more by the society itself. The fact that the activities of these various groups are reasonably well integrated into the total workings of society, without the necessary conscious control of any one individual, is indeed remarkable. This phenomenon is often regarded as just a matter of fact situation, without recognition that it is a characteristic of the integration taking place as a colony develops into an organism.

Society's more recent technical advances such as the radio, telegraph, television, rapid transportation, mass distribution of printed material, even such processes as a public election in which the summated desire of large numbers is rapidly recorded—all these mechanisms operate to transform human society into the integrated entity constituting the societal organism. The analogy of these processes to those which must have taken place during the development of the multicellular organism is indeed striking. The comparison of modern communications to the nervous system of the animal body, of highways and railroads to its arteries, and similar examples are, as has been mentioned, not new. However the concept that society actually constitutes an organic development of living matter, consistent with established evolutionary pattern has, as far as the author knows, never been clearly stated and certainly has never been presented as part of a general theory of the evolution of matter. Understanding of mankind as an evolving bio-social entity, permits insight into human society from an entirely new perspective.

INDIVIDUAL SURVIVAL IS BECOMING DEPENDENT ON EXISTENCE WITHIN THE COLONY

The survival possibilities of the individual human component of modern society are coming to depend ever more upon the internal rather than the external environment. To clarify this, it should be stated that by the term "internal environment," as used in this book, is meant the total social surroundings in which the individual lives. The expression "external environment" will be used to refer to the ambient that is provided by inanimate matter, as well as that resulting from the presence of other species. Now it is evident that for any animal which shows social tendencies, an internal environment begins to exist, gaining importance in respect to the external one as the social cohesion of the species increases. When so viewed, the evident importance of internal environment for man, serves as an indication of the extent to which the social integration of human society has already proceeded towards the formation of an organic entity.

If in our time an individual human being, or a small group of people, are placed in a wilderness without being aided by very special equipment, they will perish, unless conditions happen to be unusually favorable. Yet a wilderness is essentially nature as it would exist if man were not present. It is external environment in relatively pure form. In the same wilderness animals can survive even under relatively adverse conditions without necessarily depending upon mutual assistance. However, modern man cannot do so. It is probable that members of more primitive cultures would stand a better chance of survival. Our ancestors living say 25,000 years ago, however, managed quite well. They had none of the special equipment we would find necessary today, nor were they, in terms of their physical structure, substantially better fitted than contemporary man for life in such an environment. At present, for example, the Polar Eskimos live under exceedingly severe conditions in very small groups; at times an individual even lives alone for a considerable period of time. Individuals of southern Eskimo tribes, physically not different from the northern variety, find doing so far more difficult!

What is the reason for this situation? Is it merely a question of skills enabling the members of most primitive cultures to live in a near wilderness, which become lost as a culture advances? Or could it be that this process is inevitable as the social integration of man proceeds? Ability to live in unmodified nature appears to become gradually lost as the degree of mutual interdependence increases and as the ability of the colony as a group to cope with the environment becomes greater. This situation is again somewhat analogous to what happens to cells in cell colonies which perish when separated from the colony, while genuine monocellular creatures are quite able to live individual lives. The inability of the component members of evolving organisms to get along on their own, consequently becomes a causating factor making for the continuation of the integration process. That much is quite evident. What is not so apparent, yet probably more significant,—is that there are good reasons for viewing the action of the societal organism upon the ambient as arising out of the need of the organism to preserve and enhance its orderliness in a relatively disorderly environment. These reasons will now be discussed.

THE HUMAN SOCIETAL ORGANISM INCREASES THE ORDERLINESS (EXTROPY) OF ITS IMMEDIATE SURROUNDINGS

If one considers the extropy level of civilized human society and compares it with the extropy level of a non-organized collection of individual human beings, then there can be no doubt that the civilized society constitutes the more highly organized system. This means that the process of social integration involves a substantial increase in the extropy of the matter involved. The process is consequently consistent in direction with prior evolutionary development. Together with the increase of the organizational level of the biological sub-units, another highly significant development takes place, as the societal organisms begin to evolve. Namely, the biological material endeavors to affect the immediate surroundings in such a fashion as constitutes a decided raising of the organization of this surrounding material. By comparison, other higher animals show this tendency to only a very slight extent. Such animal instincts as result in the building of nests, the fashioning of habitations in the earth and the food storage habits of certain species, are examples of some slight modification of surroundings in the direction of raised organization. The most far-reaching change of this kind among the mammals, is brought about by the beaver, an animal which may be considered to have developed a measure of colony formation. Orderly modification of surroundings is actually more evident among those species of insects which have formed well-integrated colonies. Although the structural complexity of an individual insect member of the colony seems lower than that of a mammal, the extent to which an insect colony increases the extropy of its ambient is greater than it is for any mammal, except man.

Apparently, once the development of living matter has begun to reach the "societal stage," the raising of the organization of the immediate surroundings becomes a concurrent feature. The proximate causes for this become evident, if one analyzes the initial mechanism by means of which this modification of surroundings takes place.

Two problems which face all living creatures are the securing of an adequate food supply and some degree of protection against the elements and against enemies. Effective solution of these problems for a large number of individual animals living in close proximity must, of necessity, exert a modifying effect upon the immediate surroundings. This effect is enhanced, once the problems of food gathering and protection of individuals gives rise to the fashioning of primitive tools and weapons. As the mere gathering of fruits and hunting of animals proves inadequate to the needs of the developing society, planned cultivation and husbandry start to appear. This must become particularly true as the population increases. Once this stage is reached the extent of the modification of the ambient becomes very appreciable. It seems probable that the learning of the use of fire was a potent factor in accelerating this development. The degree of development that is needed for the consistent attainment of the tool-using stage has so far only been achieved by the human species. It appears likely that a reasonably well-developed system of communication between individuals, and also from one generation to the next, must exist, to permit such skills to develop. Consequently, considerable semantic development must have preceded the first consistent use of tools.

Modern civilization is unthinkable without its implements, which, when regarded in the most general terms possible, are matter arranged in a highly organized pattern in such a fashion as to accomplish certain utilitarian purposes. Our tools and machinery are matter so arranged. So are books, radio tubes, clothing, houses, entire cities, works of art and musical scores.

If indeed all of these implements were suddenly taken away from society, the status of the surviving individuals would probably for many generations revert to an extremely primitive level.

It is in this connection of interest to note, that the first societies to develop a reasonable level of culture at the dawn of history, devoted a considerable part of their total energies to the fashioning of elaborate totems which apparently had little immediate functional importance. The building of pyramids and temples falls clearly into this category. These structures certainly had no direct effect upon the food supply or protection of the tribe, even though they were usually intended to accomplish these aims by appealing to the proper deity. Interestingly enough they did in their own way serve their purpose. Not of course in the manner officially proclaimed—but by serving as seats of theocratic and secular power which were essential for the continuing integration of the social body. It therefore appears that many of the activities of society which have been regarded as non-utilitarian, have actually a very definite utility, as they are intimately associated with the societal integration process.

This concept sheds light on the function of art in society and should help to clarify many questions in aesthetics. Art from the earliest times has been more than an attempt to imitate the things found in nature. It arose out of man's need to create order in his environment. Art is therefore an expression of this need. It portrays such orderliness as man sees directly in nature; creates new patterns of orderliness representative of man's social activities, and serves to fashion the totems and symbols necessary for continuing integration of the social body.

It is noteworthy that the phenomenon of this "apparently non-utilitarian" construction appears in all cultures once they have reached a certain level of complexity. It certainly persists vigorously up to the present day.

EFFECT ON IMMEDIATE SURROUNDINGS MAY BE A THERMODYNAMIC NECESSITY

If one views the development of the societal organism from a thermodynamic point of view, one might expect that its very high level of extropy could raise serious problems in connection with survival. It is known that the long-term maintenance of any relatively non-random structure presents difficulties in a universe in which physical processes generally proceed towards greater randomness. One would expect that the preservation of a high degree of organization for any particular system should become more difficult generally, as the differential between the respective levels of extropy of the system and the surroundings becomes greater. This consideration certainly holds true if one considers the entropy relations of ordinary processes. A hot body loses heat faster to the surroundings than a less hot one. A cube of ice will melt faster as the temperature of the ambient increases. Complex organic chemical compounds generally break down more readily than simpler ones, as the temperature is increased. Living matter is even more sensitive to high temperatures which above a certain level inevitably produce death.

As living matter becomes more complex, its chances of remaining alive become more dependent upon its ability to overcome the increased "randomizing" pressure of its surroundings. The development of the societal organism results in a very considerable increase of complexity of organization. The problem of perpetuation of a system of such a higher order of complexity in an environment which is far more random, is consequently a difficult one. One way in which the effect of the differential between the extropy of a system and its surroundings could be minimized, would be to insulate such a system with material arranged in such a fashion, as to represent an intermediate layer, that exhibits an entropy level somewhere in between the level of the system and the more general surroundings. Such a phenomenon actually appears to be taking place. Therefore, one may conclude, that the tendency of the societal organism to modify its surroundings in an orderly fashion, is the consequence of nothing less than thermo-dynamic necessity. This consideration should be of great theoretical significance. It relates the survival problems of bio-social organisms to those established for systems on lower levels of complexity.

On this basis one can ask the question, does not much of this transformed material actually constitute an integral component of the "body" of the developing societal organism? The answer to this is a qualified yes, although much does of course depend on the definition of the nature of the boundaries of the organism. This situation is even further complicated by the fact that the development of the human societal organism is presently still in its initial stages. This fact alone would make the drawing of boundaries nearly impossible at this time.

Finally, clearly fixed spacial limits of a societal organism may not exist in the same sense in which they are known to exist for other living creatures, since we are really dealing with an evolving organism on an entirely new level of complexity. In any event the concept of non-living matter constituting part of the body of a living creature should not be too difficult to accept. After all, part of the bodies of many animals are constructed out of "non-living matter," much of which is not even composed of proteins. Examples of this are the bones and teeth of the higher animals, and the shells of many of the invertebrates. As an example, the shell of a lobster is very much part of the creature, yet its chemical composition is chitin and it is not organized into living cells.

CONSCIOUSNESS CAN NOT BE AN ATTRIBUTE OF AN ISOLATED HUMAN BRAIN

At the time a human being is born, his mind contains no significant material acquired through sensory perception. Outside of certain instinctual drives which are transmitted via the genetic pattern, the mental makeup of any individual is a function which depends upon the properties of the nervous structure of the creature and the integrated sum of all the perceptions that have impinged upon this nervous structure. The total function is clearly a very complex one, as it not only includes the perceptions themselves, but also such concepts as are formed on the basis of these sensory perceptions and the multiple interactions of these concepts. It is obvious that the proper integration, storing and scanning of this perceptual data calls for a highly developed and complex central nervous system. However, for any finite level of complexity of structure, there exists a maximum capacity for memorization, speed at which information can be scanned, total concepts that can be simultaneously associated and of integrative faculties.

Now it is also true that the number of sensory perceptions that the developing mind of the human infant receives either directly or indirectly from other human beings, constitutes the vast majority of the total number of significant perceptions received. Many of these perceptions, however, are already quite complex in terms of their contents, as they are the result of generations of human experience and thinking. Consequently the great majority of our concepts are in fact developed as a result of the integration of experiences and ideas that is taking place as the human societal organism is developing.

Members of primitive cultures possess a brain potential equivalent to that of civilized man. However, many of our concepts are completely lacking in their thought processes. The language of such groups frequently does not contain words for numbers above the first few numerals. Yet, an infant removed from such a group and raised in modern society will on the average share the conceptual characteristics of the society he is raised in. His central nervous system becomes a repository of some of the common knowledge of the societal organism that he is a part of.

As integration of human society proceeds, the relative amount of isolated thinking performed by individuals diminishes. Individual thinking, becomes gradually replaced by a process that has aptly been called "inter-thinking."

One of the most remarkable achievements of the human mind is its ability to be conscious of itself and its functioning. When one considers that the human organism, of which the central nervous system is clearly a part, is in reality nothing but exceedingly elaborately organized matter, consciousness represents actually a situation in which matter has become aware of its own existence and to some extent of its nature. This is indeed such a remarkable circumstance that it has frequently been considered to be beyond the possibility of any scientific understanding. This situation has formed the basis for much mystical speculation. Such speculation has at times led to the belief that man is in some fundamental aspect different from all other creatures and that his mind must contain some principle not explicable in terms of it being an extremely complex aggregate of matter.

It is indeed true, that man is fundamentally different from any of the other animals. But it is not individual man in terms of his structural makeup who is so very much different; it is the fact that man is a component of a societal organism in the process of formation that accounts for the vast difference. Even as relatively recent as during earliest historical times, man's knowledge of his own structure, both from an anatomical point of view and certainly from a biochemical standpoint, was practically nonexistent. Yet man of that period was structurally, and this includes the potential of his central nervous system, scarcely different from the present-day species. What has occurred since that time is not so much a change in individual man, but integration of individuals into a societal pattern, concurrent with societal accumulation of knowledge. If one is to regard consciousness in terms of its most generalized significance, namely as matter being aware of its own structure—then consciousness is certainly of recent historical origin. Of course one may also regard consciousness as simply meaning that an individual living creature is aware of his own existence. This kind of consciousness certainly has existed since the earliest historical times, and probably dates far back into prehistory. Awareness of one's own existence is a feeling, the existence of which is a matter of degree. Animal psychologists differ as to whether any such awareness exists among the higher animals. Their differences are probably largely due to lack of common definition of the meaning of awareness, as well as the intrinsic difficulties encountered in investigating the subject. Awareness is a mental attribute which probably has no clear beginning in evolutionary history, but gradually evolved in the higher animals, reaching a level in prehistoric man, where awareness of existence may be taken for granted. Certainly awareness must have preceded the more remarkable consciousness of present-day man. While awareness appears possible for a complex multicellular creature, real consciousness (defined as awareness of structure and nature) seems possible only in a societal organism in the process of formation and may well be a concurrent feature of its development, provided the initial units are of a sufficiently high level of complexity.

Is there any possibility that this kind of consciousness could exist in the mind of even the genetically most favorably endowed man who has been raised in complete isolation from society?

While the knowledge associated with this consciousness exists in the minds of individual human beings within society (to a greater or lesser extent depending on the individual), the full structure of this consciousness involves the entire developing societal organism. This structure includes such diversified matter as the central nervous systems of many individual men. It properly includes the matter comprising manuscripts, books and other records by means of which intelligence is stored and transmitted. One might even include in the structure such members of human society, who although they do not contribute directly to the advancement of ideas and knowledge, are nevertheless through their existence making it possible for others to do so. One can therefore state that consciousness, the most celebrated achievement of the human mind, is in reality a manifestation of a developing mind (or its equivalent) of the evolving human societal organism. When viewed as such, human consciousness, while still a marvelous phenomenon, becomes more comprehensible.

This analysis of the nature of consciousness is open to the following objection. If all of society were to be destroyed except for isolated individuals, these individuals would still possess their initial consciousness.

Consequently it can be argued that consciousness does not really require a structure more complex than that of a single human brain. This is true enough as long as it is applied to a static condition of human consciousness, once such a condition has already been established. However the objection does in no way indicate that consciousness could possibly have developed independently in any human being who has always been completely isolated from society.

There is no question that the total knowledge effectively available to society today, greatly exceeds that contained in any single human brain. Even though the knowledge of individuals has increased during the past few thousand years, the total knowledge of society has increased at a faster rate. This means that the ratio of societal knowledge to average (or even maximum) individual knowledge has been getting larger. It is likely that this ratio will keep increasing at a faster rate in the future, as the potential of a single human brain structure has its limits. Already today, from twenty to twenty-five years are required for the education of a scientist. Unless individual man grows vastly more intelligent, the detailed knowledge available to any one person cannot become much greater, although there seems to be considerable room for improvements in the quality of that knowledge. Further intellectual progress therefore depends more than ever on the societal integration process. The stage for the development of a more clearly emerging "mind" of the societal organism is now set.

WHILE THE HUMAN SOCIETAL ORGANISM IS EVOLVING, ALL OF ITS NEW QUALITIES ARE DIFFICULT TO EVALUATE.

Throughout the period of recorded history, and probably preceding that period, the long term trend in human society has been in the direction of increasing the size of the cohesive units of society. The growth of the social units was accompanied by an increasing complexity of the internal control system essential for proper function. At this time the average individual, even though functioning effectively within the entire social structure, is often unaware of the mechanism and nature of this structure. Even those individuals in key positions within this structure, who are able to exert control over certain phases of its functioning, cannot possibly be aware of all the detailed processes essential to such function. Yet the entire society does function.

This process is not so different from the integrated functioning of a multicellular animal, in which the individual cells have no knowledge whatever of their role, nor of the entire organism, yet where the organism also functions as an entity in a highly integrated fashion. The reader, at this point, may perhaps wonder that if the analogy drawn is really valid, how then can it be possible than human beings are to some extent aware of their functions and of the existence of society? How can an individual in the developing societal organism, as he is per analogy essentially a cell of that organism, possibly be aware of the larger entity? The answer to this apparent paradox lies in the fact that while the parallel between the societal organism and the multicellular organism has validity in terms of overall interpretation, it must nevertheless not be carried too far. There are very important differences.

It must be kept in mind, that the integration of multicellular animals to form a societal organism takes place on a level which is higher, by an order of magnitude, than the level on which the integration of cells forming a multicellular organism takes place. One would expect such a difference of level, as the initial difference of complexity of the participating individuals, cells on one hand, complex metazoa on the other, is in itself a difference of similar magnitude. On the basis of such considerations, one can expect the fully developed societal organism to be as superior in effectiveness in respect to its components prior to integration (one of the higher animals), as a multicellular animal is in respect to a protozoa.

Consequently the prediction that future man will be a cell-like creature within the societal organism is not a warranted conclusion. Such an interpretation would in fact be based on a misunderstanding of the nature of the integration process. Part of the very basis for the to-be-expected superiority of the societal organism is the high, initial complexity of its constituent units. Reversion of these units to a cell-like status would in fact be analogous to a reversion of cells in metazoa to a molecule-like function. Such a reversion does not occur. It is certainly true at this stage of biological evolution, that the repository of the principal components of intelligence which constitute the totality of human knowledge is still the central nervous system of individual human beings. Without individual man who is able to read, understand and function, our libraries and our gadgets would become useless. The apparently high extropy level of the matter constituting these things would become dubious. However the probable continued existence of the consciousness of individual human beings for quite some time into the future, does not contra-indicate the development by the societal organism of a "mind" of its own. Such a "societal mind" will be made up of the integrated intelligence of many individuals in society. As has been discussed, its scope even at the present, vastly exceeds the knowledge available to any one individual.

The thesis that human society has an organic nature which is developing rapidly in the direction of a bio-social entity, is probably a statement that many individuals will find difficult to accept. It is perhaps, psychologically, an unduly severe blow to the individual human ego to have to accept oneself as an integral component of an organism in the process of formation. The sense of human aloneness and the feeling of isolation from our fellow man, which is so prevalent particularly in intellectually inclined people, in present day American society might on first analysis tend to contradict the theory. Yet, is not the very existence of these feelings perhaps an indication of a psychological need for the integration? In any event, personal misgivings should certainly not bias one's investigation of a radically new point of view.

Let us not forget that human society right now is very much in transition and all of us are very subjectively involved in the entire process. It is therefore essential that one exercise uncommon rationality and exclude emotional bias as far as is possible, in order to grasp the full significance of the process responsible for the formation and the present transformation of human society.

It appears probable that the recognition of the biosocial nature of the forming human societal organism, will add conscious direction to unconscious pattern and consequently accelerate the process.

CHAPTER VII

Human Destiny and Evolution

One of the tasks which the writer hopes this book will accomplish is to provide a unified view of the process of evolution of matter up to the present time. In order to do so, the relation between theoretical thermodynamic considerations on one hand and biological events as they have actually taken place on the other, has been emphasized at the risk of being repetitious. This repetition may have led the reader to consider much material as obvious and some of it may have escaped proper consideration. In any event, it might be well to summarize some of the data that has been presented, in order to evaluate it more clearly and to see whether any further conclusions can be drawn from it.

On the basis of this data it appears that the long term development of a small portion of matter has over a great period of time proceeded in a direction contrary to the one indicated by the Second Law of

Thermodynamics to apply to physical processes in general. This does not imply that any of the physical or chemical processes that go on inside of living organisms fail to follow the Second Law. What it does indicate is that under certain conditions significant portions of matter will progressively increase their extropy level and succeed in doing so over vast stretches of time. This behavior of matter may be an occurrence explicable on the basis of probability considerations governing very large quantities of matter and taking place provided enough time is allowed for random changes to produce an extremely large number of possible combinations. It appears probable that very special environmental conditions regarding temperatures and the types of materials available, are necessary for this phenomenon to proceed to the extent it has on the earth. It may well be that local complexification of matter (at the expense of entropy increases elsewhere) is subject to a law just as fundamental as the "Second." If such is the case, development of life can be expected, wherever environmental conditions were at all similar to those at one time prevailing on the earth. Under certain other environmental conditions local decreases of entropy level may lead to forms of "life" quite different from the kind we are familiar with. While the trend towards a local increase in extropy is probably a universal tendency (perhaps a basic law of nature) it is unlikely that this increase of organization proceeds as far as the development of life, except where the environment is right. However, considering the exceedingly large number of stars in the universe, a considerable number of which may have planetary systems, life, although a comparative cosmic rarity, may yet have arisen in an appreciable number of localities.

The process of this development of matter has been the following: "Complexification," integration of the increasingly complex units into a new entity; further complexification of the new entity leading to a new integration on a higher level, and so forth. At a certain complexity level of this development life makes its gradual appearance, evolving further along the lines of the established pattern. It is the successful solution of the problem of preservation of its high extropy level, which imparts to matter that has reached this certain level of complexity, the characteristics of living matter. The struggle of life to maintain its precariously high level of orderliness, is commonly termed the struggle for survival. In all the more complex forms of life, survival of the species can only be assured by means of an exceedingly complex reproductive process. By means of this process the species overcomes the ultimate effect of the Second Law. The individual, however, cannot be preserved indefinitely, but must always suffer death. For the species as a whole there occurs the constant trial and error process of mutation by means of which survival in changing environment is attempted. The solution of the problem of survival is consequently pragmatically determined for any species and the resultant outcome determines its manner of further development.

From the overall consideration of the evolutionary process, it would appear probable that after a period of complexification of the multicellular organisms a new integration step will take place leading to the formation of an entirely new organic entity—namely the societal organism. Analysis of the nature and history of human society, as well as study of the colonies established by other species, make it apparent that such an integration process is presently taking place. Many aspects of human society, man's intelligence, man's control over his environment, his political history and even the "miracle" of consciousness appear to be a result of this integration process and are among the unfolding properties of the new entity. These new properties appear to be necessitated by the to-be-expected "thermodynamic problems" confronting living matter that is in the process of increasing its organizational level by still another order of magnitude.

The formation of a societal organism from the human species, is proceeding at a surprisingly fast pace, as compared to the period of time required for the complexification of multicellular creatures. Considering the rate at which this integration appears to be taking place, it is reasonable to expect that a human societal organism constituting a distinct bio-social entity will come about. The capabilities that may be expected from the fully integrated entity should be enormously greater than those possessed by human society at its present stage. This increase of capabilities (and this includes the degree of consciousness) should be many times greater than the distance that now separates the most primitive cultures known, from modern industrial society. At our present evolutionary stage, the integration process of the human species has barely gotten started. Consequently the human societal organism, to the extent to which it can be considered to exist at this time, is extremely primitive and just appearing to become recognizable as an entity. As to the relationship of the individual human being to the societal organism, valid conclusions can probably not be drawn at this stage of development. However it does appear quite certain that further human progress will not result merely from the biological improvement of individual man. It will be the integration process, the formation of the new organic entity that will determine the future development of man.

The further evolution of human society would be greatly affected by the development of a reproductive system operating on a societal level. The development of such a feature is to be expected on theoretical grounds. As has been discussed, it has already taken place in the incipient societal organisms of various insects. While it does not as yet exist in human society, its probable nature can even now be charted. No more than a few generations may separate us from its development.

The first roots of such a societal reproductive system will grow out of the present necessity for birth control, coupled with an increasing trend in the direction of conscious eugenic selection. The effectiveness of any, at this time practicable, eugenics program is however somewhat limited, not only by the obvious social and ethical problems, but more fundamentally by the underlying genetic difficulties, especially those of recognizing recessive mutations. Furthermore, such a program could at the very best, only prevent perpetuation of the least desirable characteristics and to some extent further the transmission of the most desirable ones. After all the bulk of human offspring would still come from the part of mankind endowed with average characteristics. An entirely different situation would prevail, were it possible to sire future humanity from the best fraction of a percent of the human race.

Progress towards the culturing of human genetic material outside of the human body and success in fertilizing such cultures and raising human embryos, will make it possible to utilize only the germ cells of a few selected individuals to perpetuate the entire human species. Once this is achieved, the logical necessity of the needs of the integrating organism, will probably force society to adopt this method, despite of the social and moral barriers which at the present would seem nearly unsurmountable. The result of such a societal reproductive system will again greatly increase the rate of societal integration and must within a few generations after its general adoption completely transform the nature of mankind.

Perhaps a word of caution should be injected at this point. This concerns any attempt to draw what might be called socio-political conclusions from the physical and biological data presented here. While it is certainly true that the concept of the human societal organism will eventually alter man's theory of society, every effort must be made at present to avoid rationalizations by means of which political doctrine is held to be in accord with natural law. This is easily recognized when the political views expressed are contrary to ones own. However when the opinions expressed are in accord with our own views, the nature of the rationalization is less easily recognized. In either case, conclusions so arrived at have the habit of becoming dogma which channelizes scientific thought along lines which are politically acceptable. This situation which so seriously impeded the progress of human knowledge during the middle ages, is again making its existence felt in many parts of the world. We must be on guard against this trend; if unchecked it could contribute toward taking civilization back to the dark ages, made darker this time because of the new means of destruction placed by science into the hands of self-justifying authority.

The pattern of past evolutionary history indicates that the process by means of which human society is now becoming more and more consolidated will continue, until an entity with an organic existence of its own is formed. Human individuality as it exists today will undergo drastic changes as the societal organism evolves. It is difficult to believe that the individual human constituent of an eventual societal organism would closely resemble present-day man, especially in regard to psychological makeup. Presently, however, the desire of individual human beings to live better, happier lives, constitutes one of the forces pushing in the direction of the integration that is taking place.

As has already been mentioned, the concept of the evolving societal organism is certain to have profound repercussions in the social sciences, especially in Anthropology, Sociology and Psychology. As it is the purpose of this book to present basic ideas, discussion of their full implications is beyond the writer's present scope.

CHAPTER VIII

Epilogue

There are certain further conclusions that may be drawn from the material which has been presented. In contrast to the matters discussed up to this point, which the writer hopes have been well established, the ideas that will now be presented are entirely speculative in their nature and should be considered apart from the rest of the book. One may, as a matter of fact, thoroughly disagree with these final ideas and yet be able to accept the presentation up to this point as fundamentally sound.

The conclusions that have been arrived at so far, concerned the pattern of past evolution as well as some of the consequences this pattern is likely to produce in the near future. The speculations that will now be considered are arrived at by extending the known portion of the graph of evolution over an exceedingly long period of time. Clearly such an extrapolation is of a low order of validity, especially as not all of the factors determining the known portion of the curve are fully understood. It is also in danger of being too subjective as the interpolator himself is part of the data which he utilizes for the extension. Yet, extension of the graph might help us to provide some sort of answers to questions which men have been asking through the ages.

Just what is the meaning of life? Does it have a purpose? Where is the development of life leading? Is life not perhaps just a sort of accident without any real cosmic significance? What is the true nature of the universe; that of time, space, mass and energy? Is the universe itself purposeful? And finally, are scientific answers to questions such as the ones stated possible within the limitations of human comprehension?

Which human being in whom at least a glimmering of imaginative curiosity is still alive, can resist the attempt to extend the graph? Let us then see, if by doing so, any contribution can be made towards providing answers to the fundamental questions raised.

On the basis of the pattern of the evolutionary development of matter into living forms, it would seem unreasonable to assume that the integration of multicellular organisms to form a societal organism will be the final step in the development of living matter. If such a termination were to take place it would mark the end of progressive evolution and constitute a discontinuity of what seems to have the quality of a basic process of nature. Therefore we shall assume that the established pattern of development will continue. The immediate consequence of such a continuation of the established pattern points towards a long period of "complexification" of such a societal organism (or organisms) as may form on the earth. During this period of increasing complexity the control of living matter over the surroundings should advance to a sufficient extent as to make it possible for societal organisms to establish themselves in other localities of our solar system and perhaps beyond that. After such a period of increasing complexity, one would ultimately expect another integration step to take place, leading to the formation of some sort of "super-societal organism" which would again continue to increase in complexity. All this does indeed sound fantastic, like some wild ideas out of a "science fiction" story. The writer is therefore reluctant to present these ideas. Still, are they not the result which appears to be a reasonable consequence of a continuation of the established pattern of evolution? After all, the very existence of conscious life in the universe is a fantastic phenomenon. We should not permit our imagination to become frightened just because our reasoning leads to results which seem extraordinary.

About the nature of such a "super-societal organism" we can hardly even begin to speculate. We certainly lack all specific data for so doing. Furthermore our present level of comprehension does not suffice for a real understanding of such an organism. Therefore no attempt will be made to draw any physical picture. We shall limit ourselves to the attempt to predict some of the attributes of the organism. On this basis it appears reasonable to assume that the ratio of effectiveness and consciousness of such an organism as compared to present-day man, will be of about the same order of magnitude as the ratio of these qualities in modern man compared to those in a cell colony. The vistas which such a development opens, are staggering in their implications. Certainly, if the increase of capability and consciousness will be anywhere near as great as our suppositions lead us to believe, then answers to present-day man's unanswerable questions will become quite possible. Full understanding will probably turn out to be of a nature utterly inaccessible to the human mind at this time. Perhaps the very questions will be found to have been improperly put. So when it is concluded that full answers to the fundamental problems cited seem beyond human comprehension, then this conclusion applies to the presently existing human mind, but not to the consciousness of some organism that will live some billions of years after us—yet whose ancestors we may chance to be, just as some primitive cells about one billion years ago were our ancestors. There is, after all, no reason for believing that the level of insight into nature that human beings have presently attained marks a limit, at least from an order of magnitude point of view. Scientific advances of the past century have increased our understanding of the world we live in enormously, yet have raised entirely new questions. This process should accelerate, as integration of the human societal organism proceeds at a quicker pace. Full comprehension of nature, however, must be relegated to a higher level of integration, in the very distant future.

The control over other matter that such a supersocietal organism representing a higher level of integration will be able to exercise is beyond ordinary conception. It should again be greater by about the same ratio by which the control that man is able to exercise now, exceeds that possible for a primitive cell colony. An increase of control by such an order of magnitude brings us quite conceivably to a stage where the living material of the organism will control the non-living portion of matter in such a fashion as is necessitated by its problem of preserving its own extremely complex organization.

Eventually then, if we are extrapolating correctly, living matter succeeding in controlling cosmic processes will ever more completely control the nature of the universe as well as comprise in its own entity an increasing portion of the material in the universe. This, drawn to its inescapable conclusion, means that the entity of living matter will become ever more identical with the entity of the universe. If this is true, then it means that the evolution of living matter is moving in the direction of a conscious universe. This conclusion may seem utterly fantastic if considered in the light of present human limitations in contrast to the immensity of the cosmos. Still is it not equally fantastic, yet true, that the matter that constitutes man has, if considered as an entity, even now achieved some knowledge of its own structure, as well as of the nature of other matter. So perhaps the glimmering of consciousness which man, a tiny portion of the total matter of the universe, has already achieved, is just the dawn of the great developments in evolution that are yet to come.

Selected Bibliography

Beaver, William C.: *General Biology*. C. V. Mosby Co., 1946.

Blum, Harold F.: *Time's Arrow and Evolution*. Princeton University Press, 1951.

Dunn, L. C. and Dobzansky, Th.: *Heredity, Race and Society*. New American Library, 1946.

Hoyle, Fred: *The Nature of the Universe*. Harper & Bros., 1950.

Huxley, Julian: *Man in the Modern World*. New American Library, 1948.

—— *Evolution: The Modern Synthesis*. Harper, 1943.

Jones, H. Spencer: *Life on Other Worlds*. Macmillan Co., 1940.

Langer, Susanne K.: *Philosophy in a New Key*. Harvard University Press, 1942.

Richter, George Holmes: *Textbook of Organic Chemistry*. John Wiley & Sons, 1938.

Russel, Bertrand: *The Impact of Science on Society*. Columbia University Press, 1951.

—— *Human Knowledge, Its Scope and Limits*. Simon & Schuster, 1948.

—— *A History of Western Philosophy*. Simon & Schuster, 1945.

Schroedinger, Erwin: *What Is Life?* Macmillan, 1945.

Simpson, G. G.: *The Meaning of Evolution*. Columbia University Press, 1944.

Sullivan, J. W. N.: *Limitations of Science*. Viking Press, 1933.

Index