VI

COMMITMENT AND THE STRUCTURE OF NATURE

Thus far I have been concerned with questions of method. I will expand the discussion in this chapter by presenting Polanyi's theory of the hierarchical structure of nature and the related problems of emergence, teleology, reductionism and evolution. As we shall see, the fact of personal involvement in science has metaphysical implications. These need not be conceived as established a priori, for they rest on scientific conclusions and an empirical analysis of mind. In turn, this discussion of the structure of nature will provide the technical background for understanding Polanyi's theory of personal facts and the ontology of commitment. These will be topics for the final chapter. It is at that point that we may discern the value of Polanyi's theory of personal knowledge for providing a unified world view integrating the results of all the sciences while respecting their autonomy. He provides a theory of knowledge consistent with its biological origins and with the emergence of specifically personal meaning.

l) COMPREHENSIVE ENTITIES

The discussion of Polanyi's notion of facts revealed that there is a "correspondence between the structure of comprehension and the structure of the comprehensive entity which is its object." This is because under~ standing is itself an integrating which is the discovery of an integration. If knowing is of reality, and if to know is to understand correctly, then reality is itself composed of integrations. Moreover, in trying to understand, the subsidiaries which have a bearing on the focal whole can be aspects of the object we are trying to understand. Thus, we try "mentally" or intentionally to integrate what is in fact integrated in the object. The integrating yields both thepossib1e meaning of the object and the possible meaning of the subsidiaries in the object. In The Tacit Dimension Polanyi notes that

Since tacit knowing establishes a meaningful relation between two

> terms, we may identify it with the understanding of the comprehensive entity which these two terms jointly constitute. Thus, the proximal term represents the particulars of this entity, and we can say, accordingly, that we comprehend the entity by relying on our awareness of its particulars for attending to their joint meaning.

A comprehensive entity can be either a thing or a system. We have seen that tacit integrating not only relies on subsidiaries for comprehending a focal whole, but that it too can be comprehended in the same manner. There is, then, an isomorphism between the structure of tacit integrating and the integration, or the comprehensive entity. In understanding understanding there would not be merely an isomorphism between the structure of knowing and the content, but an identity, for the structure of knowing would be the content. In general, "though, the isomorphism is less complete.

II. HIERARCHIES

It is possible to conceive of the subsidiaries having a meaning outside the comprehensive entity of which they are a part. We can think, for example, of parts outside of machines, sentences distinct from paragraphs, and chemicals, such as oxygen, which can exist outside organisms. However, each of these can also function as a subsidiary in an integration in the world. In discussing the semantical aspect of tacit integrating, Polanyi claims that the subsidiaries have their meaning in their bearing on the focal whole. What that meaning is, is ascertained by understanding the role the subsidiary plays in constituting the focal object. If a subsidiary of one integration can be understood outside that integration as a focal object in its own right, then as part of the integration it has more meaning than it would have had had it never entered the integration. Thus, the possibility of a subsidiary being integrated is the possibility of more meaning for the subsidiary.

It is possible to conceive of integrations of integrations. For example, the pieces of a chess game are integrations in their own right. We add a further set of integrations by specifying the rules for their movement. There is an integration of all of these integrations in a chess game where a first-class player has a comprehensive strategy_ Likewise, words are integrations which are integrated into sentences, sentences are integrated into paragraphs, paragraphs into chapters and chapters into books. There is the possibility, then, of successive higher levels of integration where the levels form a hierarchy.

Polanyi introduces his theory of hierarchies through a discussion of boundary conditions. Boundary conditions place restrictions, or constraints, on what they bound. As Polanyi notes, a saucepan can bound soup and a test tube can bound a chemical reaction. As will be discussed in more detail later, the laws of physics and chemistry will operate under a variety of boundary conditions. In some cases the boundary conditions are themselves integrations. They can be highly complex organizations. An example of this kind of boundary condition is the strategy of the master chess player. His strategy places constraints on the possible moves. While we are studying a chemical reaction in a test tube our primary interest will not be focused on the boundary conditions, the test tube, but on the reaction. However, in the chess game, the reverse holds. If we are accomplished players ourselves, we will focus on the boundary conditions, the strategy and not the particular rules which govern the movement of each piece. Polanyi terms the first kind of boundary condition a "test-tube type of bounds-~"and the second a "machine-type." The distinction between the two is that the machine-type is an integration of interest in its own right which bounds the subsidiary elements by organizing them. The test-tube type of boundary is not itself a principle of organization but simply prevents certain events from occurring, permitting other events to occur. We can conceive, then, of integrations of integrations where the higher integration imposes constraints on the lower integrations where these constraints are themselves integrated.

A conceptual model for conceiving such comprehensive entities is provided by

Polanyi's analysis of machines. There are conditions which must be fulfilled for the machine to exist and to function properly. Here the term "condition·' has a meaning different than in the notion of boundary conditions, and it should become clear in the following discussion. I will restrict myself here to Polanyi’s account of these conditions imposed by physical and chemical entities and laws. The machine must be made of something, and the material for its construction may be considered one of its conditions. The raw materials are understood in terms of the laws of physics and chemistry. Physical and chemical laws can be taken into account in the construction of the machine, but for the most part they are pre supposed in the designing of the machine. Thus, it is possible to fashion the raw materials into parts and relate the parts to one another in manners not specified by the laws of physics and chemistry. The laws of physics and chemistry place limitations on what can be built and they may be suggestive of innovative ideas, but they do not specify the functioning of the machine. That functioning is understood in relation to human purposes and is created by human intelligence, which grasps how to achieve the purpose by constructing the machine in a certain way. Thus, Polanyi notes that an inventor will "try to cover all conceivable embodiments of its (the machine's) operational principle by avoiding the mention of the physical or chemical particulars of any actually constructed machine, unless these are strictly indispensable to the operations claimed for the machine." Also, in many cases the parts of a machine can be made out of any number of materials and still have the same function in the machine. This means that physics and chemistry cannot explain fully why the machine functions as it does.

What physics and chemistry cannot explain are the reasons for the existence of the machine and each of its parts. Those sciences cannot ex plain why a part was made as it was, for that requires specifying what the part's function is in the comprehensive functioning of the machine. There is a reason for each part of the machine and for each successfully performed operation of the machine. "This chain of reasons is set out in the operational principles of the process or of the machine." However, as we will see later, physics and chemistry can explain some of the causes of a machine's or an organism's breakdown. The operational principles of the machine, then, can place constraints on the action of physical and chemical laws. They do not violate these laws, but the inventor exploits them in innovative ways. We may conclude that a machine is a comprehensive entity displaying a degree of organization not explicable in terms of physics and chemistry. We may conclude this simply by adverting to the semantical aspect of the tacit integrations by which we know the machine. The lower-level subsidiaries, the physical-chemical materials, are integrated into a higher order. This means that they acquire a meaning which they do not have outside that order: in this case, meaning which they do not have understood only through physics and chemistry. Likewise, chemical reactions occur in cells, but they are not random, but coordinated. Anyone of the reactions can be understood in terms of physics and chemistry alone, but their coordination cannot be. The role they play in a coordinated process is a meaning they have which cannot be understood in terms of physics and chemistry alone. I will discuss this further below. Thus, when I refer to higher orders or levels, the higher coordinates entities of the lower level. It is necessarily more complex, for it presupposes the complexity of the lower level and adds greater meaning to it.

However, there are other comprehensive entities in which the particulars are governed by the same principles as the higher It level which integrates them. For example, the sun is a holistic entity in which the parts find some of their meaning in their relation to the whole, and the whole exhibits properties which the parts do not. There are at least two levels of meaning, or conceptual levels, discernible here. However, the whole is explicable by the same laws that the parts are. There are, then, two kinds of comprehensive entities; those whose levels are governed by the same laws and those whose levels are not. I shall consider the latter as exhibiting at least two levels of being, or ontological levels.

A two leveled entity is subject to dual-control. The breakdown of water into hydrogen and oxygen can occur in a number of different instances, but in some cases the boundary conditions can be determined by organic principles, as in photosynthesis. The higher-level control does not violate the laws of the lower level. Instead, it exploits them by organizing lower~ level entities and events. Thus, photosynthesis obeys the laws of physics and chemistry, and it is the actualization of one of the possibilities left open by these laws. While it should be clear that the lower level is open to higher-level control, it is also the case that the higher level is subject to control by the lower, for it is limited to organizations compatible with physical and chemical laws.

However, neither level has complete control of the other. The lower level has a two-fold independence of the higher. First, the laws of the lower level are preserved in any higher integration. Second, the lower level entities can enter into more relationships than those the comprehensive entity of which they are part imposes on them. Because the lower level exhibits this independence of the higher, the higher organization is subject to breakdowns and fai1u~es. While earlier we saw that the lower level cannot provide the "reasons" for the proper functioning of a machine, it can provide the causes for its breakdown. This can be generalized to multi-leveled beings. Not only can iron rust causing metal parts to break, but viruses can invade our bodies and, 1f our immune response fails to contain them, they can take over cells and reproduce themselves, leading to sickness and, perhaps, death.

The independence of the higher from the lower is manifest in the fact that the higher imposes constraints on the entities of the lower level not specifiable in terms of the laws governing those entities. Second, as H.H. Pattee has pointed out, the imposition of constraints by the higher level provides additional degrees of freedom for the higher level; that is, the imposition of machine-like boundary conditions on physical-chemical entities can be a pre-condition for actions on the part of the dual or multi-leveled entity. For example, animals can search for food, reproduce, and sometimes think. All of these are actions of which a chemical is incapable. Thus, beings which have a degree of autonomy with respect to their physical-chemical conditions can exist. If we consider life in general we can conclude that beings which exhibit a greater degree of hierarchical complexity also have more autonomy, which provides them with a greater degree of independence from the initial conditions which led to life. The possibility of the greater degree of autonomy and the diversity of life itself are suggestive of a third aspect of independence. The existence of homologies in nature suggests that similar comprehensive results can be achieved given different initial circumstances. The higher level is not linked to the lower by a one-to-one cause and effect relationship nor need it be linked by a fixed set of many-to-one relationships. Just as different kinds of materials can be used to construct the same kind of machine and just as both sundials and watches, though different, can achieve the same purpose, so life can exist and develop in a variety of circumstances. In the broad panorama of evolution and on the smaller scale of the individual organism Polanyi finds that there are processes which possess equipotentiality. That is, there are different sets of initial circumstances, each of which can lead to the same kind of result. Organisms exhibit a "process of spontaneous adaptive reorganization, by which a predetermined end is achieved under profoundly modified conditions.tt

The relations between the two levels, then, are asymmetrical. The lower level particulars gain meanings which they do not have by themselves when they are integrated into higher organizations, and the higher level organizations rely upon the lower level entities for their existence.

Because machines are products of human invention they are good examples of the isomorphism that obtains between comprehensive entities and tacit integrating. They display the four aspects of tacit integration. The functional aspect is apparent. If we consider the parts as the particulars to be integrated, as integrated their function is the bearing on their joint purpose, which is the purpose of the machine. The phenomenal aspect is the shape and movement of the machine, which results from the manner of the integration of the parts. The semantical aspect is evident in the fact that the parts gain their meaning as parts in terms of their integration into the systematic whole of the machine. When we considered the raw material made into the parts, we saw that its shaping in terms of the operational principles of the machine gives it a meaning additional to its physical-chemical meaning. Also, in accord with the logic of tacit integration, if we do not advert to the machine as a whole, the meaning of the parts as parts disintegrates in accord with the logic of tacit integration. The fact that parts can still be meaningful as parts outside a machine is accounted for by the fact that we still understand the part in terms of the operational principles of the machine. Finally, the ontological aspect of tacit integrating is that its object exists as an integration. Machines exhibit this aspect, for they are comprehensive entities where higher principles integrate a lower manifold of particulars.

We encounter these four aspects also in understanding organisms. The ontological aspect is the fact of their existence as comprehensive entitles. Morphology presupposes the phenomenal character. The discussion of teleology will display the functional and the notion of hierarchies in nature exploits the semantic. However, once one descends below the biological level the extent of the isomorphism becomes more problematic. In dealing with unobservable entities the phenomenal aspect would not be apparent most of the time. I say most of the time, for the manner in which unobservable molecules are integrated can have phenomenal characteristics, as in crystals. Clearly the notion of function would have to be altered. Perhaps it could be supplemented by an analysis in terms of conditions. However, the entities would still be comprehensive entities since they are wholes understood through tacit integration. Thus, the ontological and semantic aspects would still be evident. These questions invite further development at a later time.

3) EMERGENCE

One could argue for the possibility of levels of being from the fact of their existence. However, since the fact of their existence 1s a matter of dispute between reductionists and non-reductionists, I will layout in a general form Polanyi's account of the emergence of levels.

A higher level of being can come into existence because randomness exists on the level below it. This means that the laws of the lower level do not account for all the events on the lower level. Because all the events are not accounted for, this provides the possibility for a higher-level control of these events. The actualization of that possibility is the emergence of a new kind of being. Polanyi explicitly relates the randomness of the lower level with 'the openness of that level to control by higher forms. He considers randomness to be an example of emergence which "offers a possibility for a new system of manipulations.” Accidental configurations of lower-level particulars can release higher-level principles of order. It is the fact that these are accidental that allows the ordering principle to be one of a higher ontological level of laws. I shall now discuss these points in a more detailed manner.

Randomness is an absence of order in a set of events. Now, there may be some order in a set of events, but to the extent that there is not the events occur randomly. This absence of order in a random situation grounds the affirmation that ~it is impossible to define the probabilities derived from the random character of a system by the microscopic details of the system." If it were, then the particulars would all be ordered in a cer tain manner which we would term random. However, randomness is the absence of order, so this is impossible.

The affirmation of randomness is compatible with the notion that events have determinate causes. ~hat 1s random is not the occurrence of a single event, but the occurrence of a set of events of a single kind. A single event can be accidental without being random. A set of events can be random, because each Is accidental. There is an unsystematic element on any level of being. This is easiest to see' if we accept the Laplacean ideal that the future velocities and positions of any particles can be determined if we know the laws governing them and their present positions and velocities. Suppose that there are two different kinds of particles, A and B, which will join together if they get within a certain range of one another. Is there any non-statistical law which determines when they get within range of each other? We can find out by examining the individual histories of each of the particles which join together. There is nothing in the Laplacean scheme to preclude the possibility of the particles having different individual histories. Indeed, we should suppose that at the time of our first measurement they were in different places, they had followed different paths, and they may have had any of a series of collisions with other kinds of particles. If in ten such unions we have ten different sets of individual histories, it follows that we may not be able to discern complete similarity in the histories. Indeed, we would not expect it. But if we cannot discern complete similarity, then any law concerning their histories would not explain everything about them. This follows because laws are universal. Thus, there is an unsystematic element even in the Laplacean scheme. What is unsystematic for that scheme is merely coincidental with regard to that scheme. The coincidence can be of two kinds. It may concern the particular event. Then it is an accident. Or it may concern the set of the events. In that case it is randomness.

This analysis provides for the possibility of a. set of determinate collisions of gas molecules with the overall result being a random sample. That is, there is no law or set of laws which governs the occurrence of the set of collisions. All that can be given is a set of differing individual histories. Though in some cases the events could be predicted, their occurrences are accidental and give rise to merely coincidental configurations.

The possibility of higher ontological levels can now be envisaged. The lack of system on the level of physics and chemistry is the possibility for a systematization of physical and chemical entities which is not accomplished through physical and chemical laws alone. In terms of the Laplacean model, the possibility rests on the existence of manifolds of particles, the relative positions of which are not explained by the laws governing their movement. They may be partially explicable by other laws which do not concern the mechanics of these particles. Such a law may govern the union of ABC. ABC may be a new thing K. The conjunctions of particles may give rise to a whole series of new things, since there is nothing on the Laplacean model to preclude it. Likewise, once we know the laws governing these things, there may be an unsystematic element. The possibility of another level of things is open. Since this possibility is recurrent, there can be a series of levels.

The emergence of an entity on a higher ontological level occurs when entities of a lower level are related in accord with laws which are not laws of the lower level. The invention of a machine would be an emergence of this type. The emergence of organisms from inanimate matter is also an instance. These laws are not actual prior to the emergence, though we can say that their occurrence is a real possibility.

Emergence can also occur on the same ontological level. For example, there are many cases of the emergence of inanimate open systems, and, after the initial appearance of life, there has been a continual emergence of new species in evolution, With the exception of randomness, then, emergence is the coming into being of organizations of entities where the organization is not brought about completely by the action of the entities themselves. Nor is it sustained by them alone. For example, the emergence of a physical-chemical open system in nature rests upon a set of accidental events which provide the possibility for a new relationship or set of relationships. The new relationship becomes one of the conditions for the continuance of the system. Thus, open systems can reach a steady state.

> The system remains constant in its composition, in spite of continuous irreversible processes, import and export, building up and breaking down, taking place .... If a steady state is reached in an open system, it is independent of the initial conditions, and determined only by the system parameters, ie. rates of reaction and transport.

In nature, then, systems do emerge which are organized in accord with principles not actualized in the configuration of conditions which evoked the system. The similarity of this account of emergence to Polanyi's account of insight is striking. In fact, insight is considered by Polanyi to be the prototypal emergence, for in this case an idea emerges which unifies previously unrelated elements. In the emergence of open systems, a "materially instantiated idea" unifies previously unrelated elements.

4) THE LOGICS OF EMERGENCE AND ACHIEVEMENT

This suggests that emergence is subject to a logic similar to the tacit logic of tacit integrations. The emergent higher principle of organization is not specifiable in terms of the unrelated particulars. Just as adverting to the particulars yields the disintegration of the whole in tacit integrating, so the absence of the higher organization yields the disintegration of the system or the relationship. Therefore, the emergence of the higher principle cannot be explained on the basis of the conditions for the emergence alone.

The same logic holds if a random situation emerges. A shuffled deck of cards is an example of an emergent set of unrelated particulars. It obeys the logic of emergence, for if we could specify how we arrived at a lack of order the process would have been orderly, not random.

In some cases, what emerges is not merely an organization, but an achievement. There are functions of an individual which, in their most basic forms, contribute to its survival or reproduction. The achievement, in its emergence, is subject ot the logic of emergence. In its recurrent operations it manifests the same general principle which makes it unspecifiable in terms of its unintegrated particulars. There is a logic of achievement similar to tacit logic and the logic of emergence. Thus, Polanyi notes that

> Our comprehension of a living individual entails a subsidiary awareness of its parts which is not wholly specifiable in more detached terms. Thus, understanding acknowledges a particular comprehensive--i.e., 'molar'--achievement of the individual itself. Since our knowledge of this molar function is not specifiable in 'molecular' terms, the function itself is not reducible to molecular particulars; it must be acknowledged therefore as a higher form of being, not determined by these particulars.

An understanding of different kinds of achievement is the key to understanding Polanyi's theory of life and of ontological levels. As we shall see, the logic of achievement is central to Polanyi's non-reductionist understanding of life.

S) ONTOLOGICAL LEVSLS

Polanyi's hierarchy of nature admits of five ontological levels. The first is inorganic and is studied by physics and chemistry. (We may term these the primary sciences, for it is also studied by geology, geography. meteorology, astronomy.) The remaining levels are found in living beings. The first three are the vegetative, animal and psychological levels. The last level is, as far as we know, found only in humans. I shall term it the personal level, for its basis is our capacity for responsible knowing and action which transcends our self-centered concerns. Now, there are levels of being beyond these. For example, knowledge is a human pro duct and is a level of integration in itself. For the most part it constitutes our culture. Different social forms can be considered as levels of being. Also, there may be levels of spiritual existence beyond ours. Now, consideration of the last takes us beyond our topic, except to point out that the ontology of levels leaves the religious dimension open as a possibility of a greater meaning for human existence. We encountered the level of superior knowledge in the previous chapter. It is that knowledge which is partially constitutive of our culture, and a level which the person enters when he embarks on a scientific career.

The first great difference in kinds of existence is between the organic and the inorganic, the living and the non-living. What distinguishes life from the inanimate is that life is an achievement. What is living is not merely a system, but an individual, active center operating in a manner which contributes to the chances of its survival and its reproduction. We can consider it as acting in its own interests, though we need not consider these interests as conscious intentions. Because it is an achievement it can succeed or fail. This is not an alternative open to merely physical-chemical systems. The failure to achieve is not always the same as a breakdown in organization which may be explicable in terms of physics and chemistry or other entities, depending on what the lower level is. It can be the failure of a living organism to function on its own level in a manner conducive to its development, maintenance, or survival.

All life exhibits at least two ontological levels. The levels are distinguished by the kinds of relationships which comprise them. In the case of life these relationships are machine-like and organismic achievements. Sometimes these are commitments on the part of an active center where that center is that to which we ascribe the organism~ individuality. At other times they are parts of processes which are themselves organized in terms of commitments by the individual, or they are lower level functions which provide the conditions for higher level activity, either positively, by providing energy for muscular effort for example, or negatively, as when certain processes ward off disease. In these cases the organic activities are evaluated similarly to the evaluation of the larger life cycle of the organism and they are understood fully only by understanding the full range of commitments which comprise that cycle.

The achievements on the various levels are diverse. One need only glance at evolution and the various kinds of plants and animals existing today to recognize this. They can be distinguished in terms of how their functioning is to be evaluated. I will distinguish two kinds of functioning.

In his Principles of Development Paul Weiss distinguishes physiological and developmental functioning. The distinction between the two is not always sharp, but it holds for the most part. Functioning which is developmental is future oriented. Present functioning leads to a different future functioning which presupposes what is growing in the present, Conversely, physiological functioning provides for the present maintenance of the organism.   Physiological effects pass away, but developmental effects permanently alter the organism,

Physiological and developmental functioning are appraised on the vegetative level in terms of health and sickness, normality and abnormality. These are specifications of the wider category applicable to all achievements, success and failure, On the vegetative level we meet the lowest level of commitment, Polanyi terms this a primordial commitment, An entity is in relationship with itself and an environment, The environment can be both nurturing and threatening. The organism takes a stand, as it were, for itself as an active center which through its own actions prevents itself from being overwhelmed by the environment, as well as using elements of the environment for its existence, Of course it does not always succeed. But this is the meaning of its existence for itself as an achievement.

I think commitment may be too anthropomorphic a term here. First, it is difficult in many plants to discern an active center, As in the cases of grasses, vines, mushrooms and even trees, there are a number of centers, each capable of living on its own if detached from the rest of the organism. Second, while its normal development and health are the result of its action, its sickness and abnormal development are the results of its failure to act. In contrast, we can consider animals' failures to be the result of action by the animal. Third, commitment, as Polanyi most often interprets it, involves an acknowledgement of a transcendent reality. Now plants and lower forms of animals may be in relation to a reality external to them. But the fact of the relationship and the acknowledgement of it are two differ ent things. Thus, when the roots of a plant grow towards water it is not clear that this is a commitment. It is also difficult in this case to isolate the center which can be termed the "agent" or to identify that "agent" with the active center of the plant as a whole. The same problems arise in evaluating physiological development of animal embryos.

However, following Piaget, it is possible to discern the rudiments of behavior in plants, if we define behavior as goal directed action designed to use or transform the environment, or to modify the organism's situation vis-a-vis the environment." The principles of behavior are immanent to the plant, though they may be released by the presence of certain external conditions. The behaviors exist as such gross movements a~ the turning of a plant towards the light or the projection of roots through the soil. Understanding the plant's action as behavior facilitates understanding its comprehensive achievements as primordial commitments.

There are two basic kinds of operations by which development and sustenance are achieved. These are machine-like accomplishments and organismic processes. Machine-like operations are fixed relationships whose reasons for existence are found in the successful functioning of the organism. They can be either physiological or developmental. Photosynthesis in a plant is a highly complex machine-like operation. There is an orderly, invariant breakdown-and-synthesis of chemicals which has a meaning beyond itself in the overall functioning of the plant. In contrast to these operations are the organismic. In these there 1s present a center of operations which can operate in a range of fields by spontaneously organizing a field. The term field is borrowed by Polanyi from Paul Weiss who defines it as the "condition to which a living system owes its typical organization and its specific activities," In embryological development there are two major kinds of development, mosaic and regulative. There are some eggs and blastulas which, if disturbed, will not develop normally. Their potentiality is fixed from the beginning.

However, there are others which if disturbed in certain ways will reorganize themselves and produce a normal embryo. The former's development is conceived in terms of a mosaic, in which a set of features is developed in line with fixed principles. Eventually the parts of the mosaic will become interrelated in the functioning of the adult organism. The latter's development is regulative in part. If it is disturbed within a certain range there is a range of alternatives open to it for achieving the same result. It possesses equipotentiality. The regulative and mosaic aspects are combined in the latter's development. As the organism develops, different kinds of fields emerge. For example, in humans one field differentiates off and leads to the development of the nervous system and the skin. Initially there is a set of cells which can become either skin cells or part of the nervous system. However, as their functioning becomes fixed a mosaic emerges. There is equipotentiality within each part of the mosaic, but the different parts do not possess equipotentiality. In other words, once development of the nervous system starts, those cells which have started developing into nerve cells will not become skin cells, but they may possess equipotentiality with respect to becoming different types of nerve cells, In animals which regenerate parts of their bodies this equipotentiality is also present as well as in plants where part of the plant, if detached, will live on its own.

However, as Weiss points out, the "mere indetermination of an individual cell could not explain why eventually it does enter a definite course in conformity with the actual situation." The explanation for this lies in the existence of "organizers". If we consider the group of cells which develop into an arm, there are parts which can be separated and the arm will still develop. However, there are parts which, if taken away, will result in the failure of the arm to develop. There is present, then, in the developing arm a set of relationships organizing its development. (For example, we may think of DNA molecules as a set of related chemicals which are also organizers.)

Now, the different parts of the mosaic must be interrelated in the mature organism if it is to function normally. For plants it appears that the overall configuration emerges quite early, and in the higher animals later on. In unicellular organisms it is there from the beginning. In addition, we can consider the organism as a whole as an organizer. An organism is an organizer and an organization of machine-like and organismic functions which is self-regulative and reproductive. An organism thus differs from a machine in three respects. It is self-organizing. A machine is organized externally. Additionally, if a machine organizes, it does so in accord with fixed principles. Organisms may possess equipotentiality. Because it is self-organizing, there is a degree of commitment. A machine cannot commit itself. Finally, an organism is reproductive. It is conceivable that machines can approach these operations, but it must be remembered that an organism does these things spontaneously. It is an active center. The active center for machines is man.

However, like a machine the various parts of the organism are inter related in terms of their joint purpose. Or, to eliminate the notion of purpose where it is not needed, we may say that the parts are interrelated in the comprehensive functioning of the organism. Their reason for being is found in the successful functioning of the organism, for Polanyi, because that functioning is both a condition for and a result of itself. Polanyi, then, has an organismic conception of biological structures. For him the parts of the entity are what they are in virtue of their interrelationships. That is, one alters a part at the risk of mutilating the whole, for the parts rely on one another for their existence.

An organism is also self-regulating. The principles of its operation are not merely a set, but comprise an organic unity, both organizer and organized, achieving comprehensiveness in a partially hostile environment, Unlike Polanyi; I think it is possible to conceive of an organic unity where the consequences of its functioning do not explain why it has its particular structure. The parts of the entity are not what they are in virtue of their interrelationships, though they cannot be understood as parts outside an understanding of their interrelationships. I will pursue the problem of teleology in the next section,

Considering the next ontological level another kind of set of relationships emerges. On the animal level sentience and action come into their own. In its more highly developed forms sentience becomes perception, and eventually intelligence and knowledge. Commitment on this level is termed "primitive". Some "judgment" about external reality is made and action is taken on its basis. There is "an effort to do right and know truly; a belief that there exists an independent reality which makes these endeavors meaningful, and a sense for the consequent hazards." Four new evaluative classes come into play.

> (1) a correct satisfaction of normal standards,
> (2) a mistaken satisfaction of normal standards,
> (3) action or perception satisfying subjective, illusory standards,
> (4) mental derangement issuing in meaningless reactions. The first three kinds of appraisals are those of a normal individual, the fourth case is pathological.

The emergence of sensing and acting is also the emergence of greater autonomy. There is the possibility for more operations of a greater variety.   Moreover, these operations are predominantly organismic as opposed to machine-like. For example, to the organism because of its mechanical nature are realized organically; that is, the hand possesses equipotentiality within a field of operation. We can integrate our hand's action in different ways to achieve the same result. If we consider the organism as a whole, there are various sets of operations which can achieve the same purpose. With the emergence of intelligence in animals, a self conscious organismic principle emerges, the tacit integration of understanding. The environment and action can be organized in different ways to achieve the same result. Greater complexity, greater autonomy, and more fully organismic operations coincide with higher achievements. Because each achievement is itself comprehensive, the higher achievements manifest a greater degree of unspecifiability in terms of their parts in accord with the logic of achievement. There is also a greater degree of unspecifiability in formal terms (or in terms of rules, for example). At higher levels of complexity organismic fields display greater degrees of equipotentiality, increasing the probabilities for unique achievements of the ends to which they are oriented. In addition, as we move to understanding in animals, the logic of achievement coincides with the logic of tacit integration. The last three points will be especially pertinent to the discussion in the next chapter of the kind of knowing necessary to objectify these achievements.

The third ontological level in living beings emerged in humans. It need not be restricted to humans, but could conceivably emerge in another sufficiently complex biological being. What in fact has emerged in us is the personal dimension. Animals are dominated primarily by their needs, and lead a largely self-centered existence. Man can transcend his self centeredness and live in a universe of truth and value. His concerns can transcend the immediate situation, his life, the particular world he lives in, to encompass all of being. He can also accord respect to his fellow men, treating them as equals. More importantly, he can recognize them as superiors and be guided by their knowledge and their ethics until he too has achieved their level. That body of knowledge is the basis of high cultural achievement. It forms an ontological level of its own into which we may emerge by appropriating our tradition in learning, but which we will not fully encompass due to the depth and breadth of the achievement. Modern science comprises part of that level.

The standards of evaluation mentioned earlier are supplemented on the human level by valuation. We analyze human performance not only in terms of right or wrong, successful or unsuccessful, but also in terms of good and evil. Failure in this sphere can be a matter of personal responsibility.

6) TELEOLOGY

Because the operations it performs are in the interests of its survival and its reproduction, for Polanyi living entities are teleological. Their teleology is internal, since it is not imposed from without, but arises naturally. The teleology of living systems need not be identified with the teleology of conscious purposes, which includes the external teleology of machines. Nor do I think that it is the teleology argued against by Nagel which considers "goals and purposes as dynamic agents." Neither is it a teleology in which future events are somehow a cause of present functioning.

For Polanyi the teleology of organisms can be analyzed in terms of reasons and causes. The "ultimate" biological reason for physiological functioning is the survival of the organism. The "proximate" reasons are the normal physiological functions. He notes that

> the reason for having valves in the circulatory system is to prevent the regurgitation of the blood; while we ascribe the causes of any regurgitation, occurring in spite of these to an

insufficiency of the valves owing to malformation or disease.

To understand why the valves exist is to understand the reason for them, which in turn is understood in terms of their "proper" function. He goes on to note that "Physiology is a system of rules of rightness, and as such can account only for health," just as the operational principles of a machine specify its proper functioning and not the causes of its break down. Polanyi's claim that biological processes and organs are explained in terms of their reasons, or functions, is similar to Wright's view that

> Saying that the function of X is Z is saying at least that:
> X is there because it does Z, or doing Z is the reason X is there, or
> that X does Z is why X is there.

Additionally, the success of present functioning must be appraised both with respect to the present and to the future of the organism. In this sense, Polanyi's notion of teleology has an affinity with Michael Ruse's analysis of the notion, though Ruse does not go nearly as far as Polanyi. For him there is a direction towards the future in organic systems which is irreducible to physical-chemical terms.

It is popular today to transpose teleological language into functional language. In this manner biology is purged of references to purpose which tend to import an anthropomorphic bent into the science. We will see that for Polanyi the attempt to eliminate all "anthropomorphism" would doom much of biology for there is some resemblance between the human subject studying life and the object of his study. However, I do think that teleological language can be transposed into functional language without loss in some cases, though not in others. Ernest Nagel in his The Structure of Science goes further and attempts to transpose even functional explanations into non-functional ones. He attempts to show that "in respect to its asserted content, every teleological explanation is translatable into an equivalent non-teleological one." It will illustrate Polanyi's position if I argue against Nagel on this point using Polanyi's principles.

Nagel recognizes the existence of directively organized systems. Put very simply, we may consider a system S. At times it exhibits a state G. G has three conditions, A, B, and C. These conditions can also exhibit different states, but it is the cumulative effect of the three conditions which keeps S in a G-state. Thus, if one of the conditions is altered, the other two will also change to compensate for the difference, maintaining S in a G-state. If they do not change, or if the change in one of the conditions exceeds a certain range so that no compensation would work, S is no longer in a G-state. Now, for Nagel, the action of the directively organized system does not require an explanation in terms of goals, purposes or functions. To illustrate this, let us turn to a simpler example of his. He states that

> … a teleological statement of the form 'The function of A in a system S with organization C is to enable S in environment E to engage in process P' can be formulated more explicitly by: Every system S with organization C and in environment E engages in process P; if S with organization C and in environment E does not have A, then S does not engage in P; hence, S with organization C must have A.

His example of such an explanation is "When supplied with water, carbon dioxide, and sunlight, plants produce starch; if plants have no chlorophyll, even though they have water, carbon dioxide, and sunlight, they do not manufacture starch; hence, plants contain chlorophyll." Now, there are problems with this account which center around the notion of necessity implicit in "5 with organization C must have A." However, my concern is not to deal with these, but with the more important claim that

> … a teleological explanation in biology indicates the consequences for a given biological system of a constit uent part

> or process; the equivalent non-teleological formulation of this explanation … states some of the conditions … under which the system persists in its characteristic organization and activities …. In brief, the difference is one of selective attention, rather than of asserted content.

Because the explanations are equivalent, both are admissible in science. However, this means for Nagel that biology is open to reduction to physics and chemistry, though it does not ensure that biology is in fact reducible. For him, the fact that biological systems are teleological would not constitute them as irreducible to physical and chemical systems.

Nagel's proposed equivalence is at odds with Polanyi's view of the hierarchy of nature. As I noted earlier in discussing emergence, and reasons and causes in machines, the conditions of operations are often not sufficient to account for those operations themselves. Thus, an explanation of the operations in terms of the conditions is insufficient. In the case of life, a Polanyian characterization of Nagel's position is that he considers dual-leveled systems on the same footing as holistic systems which exhibit two conceptual levels but only one ontological level. In the latter case the difference between levels is "one of selective inattention rather than asserted content." In the former case, however, the "shift in attention" (or understanding) to the lower level excludes the higher. In understanding life, for Polanyi, we meet the paradoxical situation of entities which are partially self-explanatory in that their existence is for the sake of their own existence. If we transpose the analysis into terms of conditions, we must acknowledge that there are activities which are conditions for their own existence. For example, the activity of eating has conditions, but it also is a condition of itself, for if an animal did not eat, it eventually would not be possible for it to eat. Likewise, the use of sunlight in photosynthesis is an activity which is also a condition for its own existence. In general, then, conditions as Nagel envisages them are sufficient to release an operation, but not to sustain it. Sustaining it requires the operation itself. If we are to transpose functional explanations into conditional ones, then we would have to acknowledge two kinds of conditions. There are conditions which are merely causes of certain operations.` There are also conditions which are reasons for operations. The reason the animal eats, though it need not know or envisage this, is to survive. But we would not claim that the reason for oxygen is so we can breathe, though we would say that the reason we breathe oxygen is to survive. The former is a condition of the first type, while the latter is a condition of the second kind. I have introduced the notion of two different kinds of conditions for the purposes of this discussion only. Polanyi strictly separates the two into conditions and reasons,

Thus far we can only conclude that if functional explanations are transposed into explanations in terms of conditions this does not leave biology open to reduction to physics and chemistry, since there are other ontological levels of organization which are conditions of themselves. However, I have not refuted Nagel's more general claim that functional explanations can be transposed without loss into explanations in terms of conditions, I do not wish to refute this claim in general, but only as Nagel has presented it. I shall expand on this below. From Polanyi's point of view, the general claim should be refuted in the following manner. For Nagel biological processes need not be explained in terms of their consequences. Returning to the example of his mentioned earlier, I should note first of all that it does not explain why plants have chlorophyll, "When supplied with water, carbon dioxide, and sunlight, plants produce starch; if plants have no chlorophyll, even though they have water, carbon dioxide, and sunlight, they do not manufacture starch; hence, plants contain chlorophyll.” Nagel cannot claim that the reason plants have chlorophyll is to produce starch, for this would explain chlorophyll in terms of its consequences. Likewise, he cannot claim that the function of chlorophyll is to produce starch. He can only claim that if chlorophyll is present along with other conditions, then starch is produced. However, this does not explain why chlorophyll is present, that is, why plants have chlorophyll. A minimal explanation is that producing starch through photosynthesis is an adaptive advantage. The emergence of this process contributed to the survival of the organisms in which it emerged and the inheritance of this process has contributed to the survival of subsequent organisms. If the maintenance of the process of photosynthesis is to be explained in terms of the survival of plants, then photosynthesis, and, hence, the action of chlorophyll in producing starch, is explained in terms of its consequences.

The weak point in Nagel's analysis is that he overlooks the implications of conditions in general. Conditions can only be understood as conditions if we take into account what they condition. That is, the notion of condition entails the notion of the condition's having consequences. Conditions, then, are understood in terms of their consequences. Thus, as I noted above, Nagel's transposition of a functional into a conditional "explanation" fails, for the conditional "explanation" cannot be an explanation unless the conditions are understood in terms of their consequences. He cannot completely eliminate an understanding of the conditions in terms of their consequences. In fact, what force his "explanation" has rests on this tacit understanding. What he does instead is eliminate reference to some of the consequences. such as survival. But this means that the explanations are not equivalent ant that the functional one takes more into account than the conditional one. In addition, it is consistent with the views of some philosophers of science to claim that while in physics and chemistry conditions can be understood in terms of their consequences, we do not need to understand the consequences to grasp why the conditions exist as they do. However, we need to do this in biology, for the conditions are what they are because they lead to certain consequences. Nowhere is this more evident than in a study of development. The organism produces the conditions for the emergence of each higher integration. In turn, the adult organism produces the conditions for the development of new organisms. Thus, an exhaustive biological explanation is the elucidation of a grand circular scheme which may occur billions of times, and where, to a certain degree, there is a complex organization of conditions and consequents where each consequent becomes a condition and each condition is a consequent, and each is what it is because it contributes to the survival of the organism. Though for illustrative purposes it may be easier to understand the set of conditions and consequences in terms of “machine-like" principles, we should remember that organisms also possess a resiliency and adaptability which rests on organismic processes.

However, while living beings are to a certain extent conditions of themselves, I do not think that it is correct to claim that the individual, simply as living, exists for the sake of itself or, for example, that “the reason for having valves in the circulatory system is to prevent the re gurgitation of the blood." Living systems have functions, but, as Grene argues, functional explanation "shows how a system, or subsystem, works, not how, as an end, it evokes its own means." Thus, survival, as "goal" or "end" is not the reason for the function, though the fact that an organism has that function may increase its probability of surviving. Survival also does not provide the etiological force which Wright attributes to it. He notes that

> If any organ has been naturally differentially selected for by virtue of something it does, we can say that the reason the organ is there is that it does that something.

However, each function must first emerge. The fact that it contributes to survival explains not its emergence, but its survival. As many have pointed out, this type of argument is circular for its form is that something survives because it survives. Thus, functional explanations which are not concerned with conscious purposes or entities, such as machines built for known purposes, should not explain a function in terms of its consequences in the sense that the function is what it is because it has certain consequences. Neither should it be claimed that X is done for Y or that the reason for X is Y, in the sense of “reason" used above. Instead, functional explanations should specify what the function is and what the results of the function are. Thus, a functional explanation would relate the function to its consequences, and the function would not be fully understood without understanding that relation, but it is not explained in terms of its consequences. However, we can claim that it survived in certain circumstances because it has these consequences.

I have arrived at a position between Nagel's and Polanyi's. The idealized circular scheme of living organisms mentioned above can be understood in terms of conditions where their conditions are functions. Each set of conditions gives rise to results which in turn become conditions and so o~. However, these conditions must be understood in relation to their consequences, for they comprise an integrated system. Teleological explanations differ from conditional explanations of this type not in terms of emphasis on conditions or consequences, but in terms of how they purport to explain functions. My difference with Polanyi is that the conditional explanation I have outlined does not permit an analysis in terms of reasons. However, I do think that an analysis of reasons and causes is appropriate for understanding machines.

Nagel's equivalence is also at odds with the fact that there are conscious purposes, and that behavior cannot be explained adequately without reference to these purposes. Though I think Polanyi can replace "reason" with "function" in the non-teleological sense in non-conscious organic operations, I think that many conscious operations are clearly teleological. They are purposive in the strongest sense, being or involving conscious intendings of ends. Again, the difference between two kinds of conditions is operative and the higher level condition is not reducible or translatable into the lower.

For example, hunger is a function 1 but it also presents many animals with a purpose. They hunt in order to get food. Hunting, then, is also a function which can have a purpose. The important point is that it would not have the function it has if it were non-purposive. Likewise, in humans questioning is a function which has a purpose (to get an answer), and it is the function that it is only because it has this purpose.

In summary, there are some functions which are what they are because they are purposive. They are teleological in the strongest sense. There are also functions which are not purposive in the sense of being related to conscious intending of results. I think they can be explained without reference to purpose. However, they cannot be reduced to or explained in terms of the conditions for their existence unless we acknowledge two kinds of conditions. One is the activity of an active center or individual which contributes to its survival and reproduction. This is an achievement which can succeed or fail. The second kind is either necessary or, along with other conditions, jointly sufficient for the emergence, survival and reproduction of living entities. Finally, as I have stated, Polanyi has a wider notion of teleology than I accept. He notes that "living machinery has a purpose only in the interest of the living individual as appraised by the observer. But it must possess this purpose." Such an appraisal may have a heuristic function. However, if "it must possess this purpose," then it does not have the purpose only "as appraised by the observer." It has the purpose in itself. I think he should restrict the notion of purpose to conscious intending and in other areas of biological explanation substitute it with function. I do not think his philosophy of biology would lose anything by this move. Indeed, it would be more parsimonious.

However, as he correctly points out, if we consider the functioning of machines we must understand it in terms of the strongest notion of teleology, for that for the sake of which machines function are human purposes.

7) VALUES AND EVALUATION

While some writers are content to distinguish biology from physics and chemistry on the basis of the teleology of organisms just outlined and argued against, or because they display te1eonomic relationships, Polanyi emphasizes the additional point that understanding life involves evaluations which are not present in understanding mere physical-chemical events. We are familiar with the most basic normative appraisals from the discussion of ontological levels. However, Polanyi goes beyond the recognition of processes which are appraised normatively to the affirmation of organic achievements as values. He states:

> … the understanding of a whole appreciates the coherence of its subject matter and thus acknowledges the existence of a value that is absent from the constituent particulars.

Because organic functioning is normative, it can be appraised in terms of rules of rightness. In understanding a machine these would be the operational principles. In understanding organisms, they are the relationships operative in a healthy specimen of a species. Earlier I criticized Polanyi for not adequately distinguishing between valuation and evaluation. I believe he makes the same mistake here. This is not to say that organisms may not be more valuable than physical-chemical processes, but that the appraisal of their value is an operation which emerges on the personal level, and which can be distinct from the evaluation of the organism. The processes are not a value for the organism if the organism cannot appraise them. Of course, they can be valuable to us and valuable in themselves, but the processes as valuable mean more than the processes as properly functioning. However, there are cases where the two coincide, and there is a greater coincidence the more personal the processes are, for the understanding of them requires a more personal involvement. This is clearly the case if we are appraising the moral development of a person. The evaluation of the person will be in the context of our own values. Any appraisal of the actions of humans would be in the context of our own values, This is also true of animal psychology, though to a lesser extent. However, what constitutes successful functioning in embryological development is not the realization of values in the sense of consciously intended "objects". While we may consider successful functioning more valuable in most cases than unsuccessful functioning, that valuing process is different from the evaluation of what constitutes successful functioning.

The levels of being of living individuals are distinguished by the kinds of achievement which they are. Since achievements are normative, and since each higher level presupposes the elements of the lower level, each higher level comprises a set of achievements n.ot operative on the lower. But since it is an integration of the lower akin to tacit integration, there is an evaluation necessary to appraise higher achievements which is not necessary to understand the lower. It is partly this higher level of evaluation which Polanyi is referring to when he "acknowledges the existence of a value that is absent from the constituent particulars." As noted f as we ascend the levels we eventua.lly come to the point where evaluation coincides with valuation.

While on the lower levels of life the value may not be there for the organism, it can be there for us. Indeed, it is not unscientific for the scientist to value his subject matter. It makes him a better scientist. In fact, for Polanyi, it makes science possible in the first place and sustains it, Thus, the evaluation can, and in most places should, be supplemented by valuation. If we accept the difference between the two in the cases where it applies, and accept the complementarity of them, then I believe it is correct to say that in appraising the higher level we can acknowledge "'the existence of a value that is absent from the constituent particulars," for there is the existence of an achievement not present on the lower levels.

8) REDUCTIONISM

It should be clear that Polanyi is not a reductionist. However, some have criticized his non-reductionist stand as insufficient to prove that reality must ultimately be understood in terms of ontological levels. I think that his critics' arguments are insufficient. Indeed, I do not think than any argument for reductionism could be sufficient. Using Polanyi's principles, I shall provide arguments for the conclusion that reality is a set of ontological levels.

There are two major problems of reduction. The first is the problem of reducing one theory to another. The second problem concerns the existence of ontological levels. Biology, for example, will be reduced to physics and chemistry if physical and chemical laws can adequately ex plain biological entities. The reduction of one theory to another can be effected in two manners. First, it may be a reduction where one theory reduces to another as Nagel understands it. Second, it may be possible that a new physical-chemical theory will be developed which will explain bio logical entities and which will replace the biological theory of the period. In this case, biological phenomena would be explained by physics and chemistry, but the replaced biological theory would not be deducible from the new physical-chemical theory. This is a broader notion of reduction more in line with Kemeny and Oppenheim's theory. The third instance of reduction I will discuss is very similar to Nagel's. It is of interest because its author, Robert Causey, think that he has refuted Polanyi's claim that biology is an irreducible science and that living things exist on their own ontological level. If biology can be reduced, then we must conclude that biology does not study an ontological level distinct from the level studied by physics and chemistry.

I will discuss three models of reduction and how Polanyi's notion of autonomous hierarchical levels can be established in the face of them. The first is

Ernest Nagel's theory of reduction. He defines reduction as

> the explanation of a theory or a set of experimental laws established in one area of inquiry, by a theory usually though not invariably formulated for some other domain.

We are already familiar with the theory of explanation common to Nagel and Hempel in which the explanandum phenomenon is deduced from the explanans which comprises a set of laws and a set of statements about initial circumstances. Because the relationship between the two theories is primarily a logical one, two conditions must be met for a valid derivation of the reduced science (the secondary science) from the reducing science (the primary science) to occur" Nagel calls these the conditions of connectability and derivability. The condition of connectability becomes problematic if the reduction is a heterogeneous reduction.

Nagel distinguishes between heterogeneous and homogeneous reductions as follows: In an homogeneous reduction the secondary science shares its vocabulary with the primary science, while in an heterogeneous reduction the vocabulary of the two sciences differs. In a homogeneous reduction the condition of connectabl1ity is met, for that condition is that the terms of the two sciences be connected. In a homogeneous reduction the terms are identical. In a heterogeneous reduction there must be some manner of connecting the terms of the secondary science to those of the primary science. Since the meanings of the terms of the secondary science are established for Nagel by the rules of usage of that science, the connecting of the terms can also be conceived as the connecting of the concepts of the two sciences. Now, in a valid derivation which from the scientific standpoint is non-trivial it is not possible for there to be a term in the conclusion which is not in the premises, Thus, unique terms of the secondary science can be connected with the primary science only if some assumption(s) is (are) added to the primary science. The second condition is that of derivability. The laws of the secondary science must be derivable from the primary science.

Now if the meanings of the technical terms of two sciences are not the same and if neither can be derived from the other, then there is some mea sure of autonomy between the two. Thus, if the sciences are biology on the one hadd and a combination of physics and chemistry on the other, then each would be autonomous with respect to the other. I shall term this autonomy "logical autonomy". It is generally conceded that present-day biology is not reducible to present-day physics and chemistry, but the possibility is left open by many thinkers that it will someday be reducible. I will show later that for Polanyi an adequate biology cannot in principle be reduced to physics and chemistry, for the sciences are logically autonomous.

A second kind of reduction is micro-reduction, in which the properties of a structured whole are explained in terms of the laws governing the parts of the whole. Causey has a complex notion of such a reduction, which I shall introduce here and develop more fully below when I discuss his specific arguments against Polanyi's theory of irreducible hierarchies. He states:

> (S)uppose that a whole, W, exhibits a property, P, under conditions, C. What is required for a micro-reduction of P? Generally, at least the following are needed: (a) a description of the composition of W (i.e., an enumeration of the parts of W), (b) a description of the relevant proper ties of these parts, (c) a statement of the relevant general laws governing objects of the level of the parts of W, and (d) a description of the structure of W. If we can now derive P from (a)-(d) in some satisfactory way, then it is usually said that P has been micro-reduced to the level of the parts of W.

This is an account of what he terms a direct micro-reduction. I will explore the problems with it and his attempt to solve these problems in his theory of an indirect micro-reduction below.

A third kind of reduction is akin to 'that advocated by Kemeny and Oppenheim. I will not present their complete theory, but rather the general line of thought it advocates concerning reduction. A first consideration is that there are problems with Nagel's view of heterogeneous reductions centering on the condition of connectability. In general, it can be shown that a heterogeneous reduction is not possible as Nagel conceives it, for the fact that assumptions have to be added to the primary science changes that science, such that the secondary science is not deduced from the primary science alone, but from a science which is a combination of the primary and the secondary sciences. However, in this case we would have a homogeneous reduction and not a heterogeneous one. However, a second point to consider is that in some manner biology may be reduced to physics and cheats try in the future if a theory is developed which explains both what are now considered to be biological phenomena and physical chemical phenomena. Such a theory would neither heterogeneously nor homogeneously reduce the present-day theories or some such substitutes for them, but would replace them. For example, Kemeny and Oppenheim propose that the new theory should "explain (or predict) all those facts that the old theory could handle" and that it be simpler than the old theory. Now, the notion of simplicity is problematic for them, for often the "simpler" theory will be more complex or difficult. However, they claim that the new theory would be simpler because it would use less language than the old theories. In addition it is difficult to defend a notion of one theory explaining the facts the other explains if the latter replaces the former, for often what the facts, observations, (etc.) are differs in the two theories, However, if one theory were to replace both biology and physics and chemistry, this would mean that there are not two ontological levels, and we could speak of biology (and perhaps even physics and chemistry) being reduced, However, an operative ideal in the philosophy of science is the replacement of biology at some future time by a new physics and chemistry, In this case biology would be reduced to that level specifically.

The basic problem in arguing against reductionism is to determine whether dual and multi-leveled comprehensive entities as Polanyi conceives them exist. If they do, then the reductionist arguments as outlined can be met as follows. Nagel's conditions of connectability and derivability cannot be met in the study of a biological organism in terms of physics and chemistry and biology because the relationships between the laws of the primary and the secondary sciences are governed by tacit and not for mal logic, just as the structure of the organism obeys the logics of achievement and emergence. The conditions of connectability cannot be met, due to the semantic relation between the two levels. Because the higher integration adds meaning to the lower-level particulars, it would be absurd to account for the added meaning by adverting to the particulars themselves. Micro-reduction suffers from the same defect. The semantic relationship is denied. Finally, if such comprehensive entities exist, then there must always be at least two sets of laws necessary to study them, for we are dealing with two different kinds of things, and the relationships between the things of one level cannot be accounted for in terms of the relationships of the other things. Thus, the ideal of one future science which explains a comprehensive biological entity is a chimera.

Since no one thinks that animal functions can be understood in terms of vegetative ones, I will concentrate on two ontological interfaces, those between the organic and inorganic levels and between the mental and the bio logical. I will consider the latter in the next chapter.

Turning to the organic and the inorganic levels, we have already seen that organic entities have an orientation to the future lacking on the inorganic level.

Polanyi also notes that sentience is a category lacking in physics and chemistry. Naturally, we do not think of molecules as sensing. How1ever, Kenneth Schaffner considers organisms to be complex physical-chemical systems, which differ in kind from other physical-chemical systems primarily in respect of their complexity. There is not any intrinsic difference which should lead us to posit any ultimate separation between biology and the inorganic sciences. If they were merely more complex systems Schaffner's point would be well taken. However, they are new kinds of things. Now it would be absurd to suppose that the properties of one kind of thing are the same as those of another kind of thing, If they were the same, then they' would be the same kind of thing. If we do not confuse the properties of electrons with those of atoms, why should we suppose that organic things have the same properties as the entities they systematize?

This may appear trivial. However, if we do not suppose that they possess the same properties, then it is possible for organic things to enter relationships which physical-chemical systems cannot. For example, sentience is a property which 1s a feature of the organism as a whole, as is eating, developing and reproducing; and none of these are features of physical chemical systems which are merely systems and not unities. In other words, none of these are features of physical-chemical systems which are not also active centers. And it 1s the activity of the center which is a condition for its own existence and is the possibility for a new set of relationships between other things which also exhibit comprehensive features different from mere physical-chemical systems. These relationships should be interpreted in terms of the center, not only in terms of what the center systematizes. If we do it only in terms of what the center systematizes. the unity of the center dissipates for our intelligence. I have already discussed related points in presenting Polanyi’s analysis of machines, and machine like and organismic structures in animals.

Polanyi's strongest argument for the autonomy of biology centers around the code-like functioning of DNA. According to chemical laws, when chemica.ls combine they tend to form stable unions. Now, if the structure of DNA were governed only by chemical laws, then we should expect that the unions of the bases would be those which are most stable. But then there would be a redundancy in the molecule of such a kind that it could not function as a code. Consider the five letters m, b, t, e and a. If we always combined b with -t and m with a and so on, this would considerably restrict our ability to form words with these letters. For example, we could not spell "meat" or "beat". However, since we understand the functioning of DNA as code-like, then, though the bases may still tend toward the most stable union, it is not the formation of a stable union which is determinative of the order of the bases. Indeed, we may consider the survival value of certain parts of the fully grown animal as partially determinative of the order of the bases.

Causey admits that the theory of the "existence" of DNA may not be directly reduced to the level of physics and chemistry, but he proposes that it may be indirectly reduced. His notion of indirect reduction is related to his view that there are at least two different kinds of explanation in physics, chemistry and biology. He notes that "Given a structure, we can ask for an explanation of its empirical possibility, or we can ask for an explanation of its existence." The first type of explanation explains the empirical possibility of structure. while the second is an explanation of its existence. He cites as an example of the first the account quantum theory gives of the possibility of an H2 molecule forming. However, such an explanation does not explain the formation of any particular molecule, but only points out that it is possible for this kind of molecule to exist. To account for the existence of a particular H2 molecule the second kind of explanation is needed "which will often be historical or genetic." In addition, the first type of explanation "leaves open the possibility that the same set of objects could form more than one structure."

Concerning Polanyi's argument about DNA Causey states:

> Polanyi correctly points out that the base sequence structure of a particular DNA molecule is not uniquely determined by the forces of chemical bonding. Thus, bonding theory can explain the empirical possibility of this DNA molecule's structure, but bonding theory does not alone explain how this particular DNA molecule came to have the particular DNA base sequence that it has. Polanyi therefore concludes that the structure of this DNA molecule is not reducible to physical chemistry. However, this conclusion does not follow. Polanyi has only shown that the existence of a particular DNA base sequence cannot be reductively explained in the same way as its empirical possibility.

Causey assumes that its empirical possibility can be reductively explained, for the laws of chemical bonding leave the possibility open for the existence of DNA. But I think we can go further than this. Not only does bonding theory leave open the possibility of DNA. In addition, a chemical analysis can tell us what the composition of DNA is, how it is put together. But this still does not tell us what DNA is. To understand fully the order of the chemicals in DNA we must also understand the orderly sequence of events in which DNA takes part. The order may be a sequence of events each of which adheres to chemical law, but the order is not a chemical law. Thus, to explain the possibility of DNA in the sense of explaining the possibility that DNA can exist is not to explain DNA. It does not tell us what DNA is.

Causey has a wider notion of possibility. There is a sense in which a theory lays out a set of possibilities by formulating a set of relationships that can exist between elements. However, Polanyi's point is that for DNA theories of chemical bonding do not layout these relationships' though they do not preclude the possibility of them. Analogously, the theory of evolution does not preclude the possibility of new species emerging, but it does not tell us what these will be. Bonding theory does not fully explain the possibility of DNA, though it does not preclude it, not can it account for all the possible relationships that may exist in DNA.

Causey agrees that the existence of DNA cannot be explained in terms of bonding forces alone. As I noted, this is because there is a difference between explaining the possibility of DNA and explaining its existence. Now I admit that there is a difference between an historical explanation and one that simply lays out the relationships which any entity of a particular kind has. However, it is a mistake to identify an historical explanation with an explanation of existence and the latter with an explanation of possibility. The latter is not an explanation of the possibility of an existent, but is an explanation of the existent itself. It is simply in general terms which abstract from what is merely particular. On the other hand, an historical explanation may account for some of the particularities, but it must be complemented by the general explanation. In other words, if we tried to explain the existence of a particular entity without reference to what it has in common with other entities of the same kind, it would not be possible to characterize the entity in such a manner that we could arrive at an adequate historical explanation, since we would not know what the entity was. we can only know that through universalizing. Thus, we find that both explanations regard the existence of the entity. Because one kind is more general than the other, it leaves open a range of possibilities. However, it only accounts for some of these possibilities in terms of its theory. In accord with my earlier remarks about emergence, other possibilities can be accounted for by historical explanations (accidental configurations) or by understanding higher laws (systematic configurations). I shall have more to say about this shortly.

Causey thinks it is possible that the existence of DNA will be explained reductively. Such a reduction would be indirect. An example is the following:

> Polanyi points out that machines are designed and built by men to perform certain functions. He also points out that the existence of. the structure of a machine is not directly explainable in terms of physical laws plus simple physical properties of the components of the machine. However, it does not follow from these two observations that the structure of machines is irreducible. If we could reduce human behavior to physics and chemistry, then we could perhaps also reduce the structure of a machine, i.e." give a chemical physical explanation of the existence of such a thing with such a structure. Of course, this would be an indirect reduction through higher levels,

Since the existence of the structure of DNA cannot be directly reduced to lower levels, it is explained in terms of higher levels. However, perhaps with a more advanced theory of evolution, it will be possible to reduce those higher levels to lower-level particulars. In that case DNA would be indirectly reduced to the level of physics and chemistry.

This is an ingenious argument, but it merely shifts the problem. If the higher level which explains the existence of DNA is in fact a higher level, then it should have operational principles which are not present on the lower level, and it would seem that this higher level could not be directly reduced either. Additionally, the lower level it is reduced to would have to be the same level DNA is on, for here we are not dealing with two different entities as in the case of men and machines. But Causey does not have such a notion of higher level in mind. In his only example of an actual indirect reduction he refers to the formation of a diamond from carbon,

> Thus, the existence of the molecular structure of the diamond sample would be reductively explained by first explaining it with the help of the higher geological level and then reducing this explanation to the atomic level.

Causey mistakenly thinks that this reveals the possibility of an indirect reduction of a higher level as Polanyi conceives it to a lower level.

However, for Polanyi geology does not study a level of being higher than that studied by physics and chemistry since these sciences embody substantially the same principles. Now, if a level higher than that of DNA can be directly reduced for Causey, I wonder why DNA cannot be directly reduced. Why should the same problems not appear in the direct reduction of the higher-level processes which explain DNA that appear in the direct reduction of DNA? In fact, the same problems do arise given Polanyi's view. Causey thinks that a reductive evolutionary explanation may be possible. However, if he is then to offer a substantial argument against Polanyi's views on reductionism he must take Polanyi's theory of emergence into account. Specifically, he must show that the conditions necessary for the emergence of life are sufficient to explain its survival, But then he would have to show that the survival of the particular organism and its reproduction are not conditional on the operational and organismic principles of the organism itself; that is, that they are not conditioned by the emergent relationships. In that case what has emerged would have no survival value in itself, and we would have to throw out one of the basic principles of evolution. This argument also applies to his notion of the possibility of an indirect reduction of operational principles in machines.

A complementary argument is presented by Michael Simon. He believes that Polanyi's argument against reduction rests on the underivability of laws of higher levels of organization from the laws of lower-level particulars and processes. He states that the

> …nonderivability of the principles of higher levels of organization from lower-level principles signifies not that the higher levels are not determined by the lower levels but only that they are not uniquely so determined.

Again he notes that

> Higher levels of organization are determined by lower levels, in the sense that they must be-compatible with the laws governing all processes on those levels, but they are not un1quell determined.

He thinks he is making the same distinction Causey makes between explanations of the existence of a structure and an explanation of its possibility. Thus, chemical laws, for example, leave open to some extent the organization which aggregates of chemicals may assume. But it does not follow from this that the origin of this organization is not explicable solely in terms of the "historical" actions of chemical and physical particles. Polanyi agrees with Simon that the laws governing the lower-level particulars must be respected if these particulars are organized by a higher principle. The key term in this dispute is "organization”. The action of a set of particulars is random to the extent that they are not bound by an ordering principle. The laws of physics and chemistry do not determine all the actions of physical-chemical particles. To the extent they do not these actions are random with respect to physics and chemistry. This seems compatible with Simon's analysis. But then, if the actions of physical-chemical particles are random with respect to the laws of physics and chemistry, but they are organized, then the principle of organization must not be a physical or chemical law. Nor could it be accounted for completely by the action of physical-chemical particles, for as physical chemical particles, their action is random. It is only as parts of a system that the action ·not accounted for by the physical-chemical laws is ordered. Thus, as soon as Simon admits that there are higher levels of organization compatible with, but not determined by lower-level laws, he is implicitly committed to at least one level of existence not explicable in terms of physical-chemical laws, elements, and processes.

Thus, it is no accident that, as Schaffner notes

> At every temporal point in the development and maintenance of the unicellular or multicellular organism, chemical systemization is present which cannot be accounted for chemically except by referring to a previously similarly organized system.

As we have seen, the emergence of the organization cannot be explained historically in terms of its antecedent conditions, since recourse must be had in the explanation to the organization itself. This is especially true of life, which is not merely organized, but is self-organizing. This point is significant not only for understanding the irreducibility of life, but also for understanding its evolution.

9) EVOLUTION

Polanyi's view of life as an emergent achievement challenges the neo-Darwinist claim that evolution can be explained in terms of genetic mutations, random genetic variation resulting from bi-sexual reproduction, and adaptive advantage. The major failing of the theory of natural selection is that it

> …tells us only why the unfit failed to survive and not why any living being either fit or unfit, ever came into existence.

The neo-Darwinists claim that genetic mutations give rise to novel structures, behaviors, characteristics which survive because they secure an adaptive advantage for the organism, contributing to its chances for survival and reproduction, and hence the survival of the characteristic in the species. Mutations are random. Thus, on this theory, adaptive advantages arise accidentally. Evolution, then, would be primarily the emergence of adaptive advantages evoked by random mutations. However, for Polanyi, this view of evolution does not account for the emergence of life as an achievement. Also, it does not account for the emergence of increasingly complex beings. Polanyi tries to account for this through a theory of phylogenetic fields. We shall see that this theory fails because of its teleological overtones. But we shall also see that we can account for the evolution of more highly organized beings on the basis of his theories of hierarchies, emergence and achievement without invoking any teleological notions until we reach the level of purposive behavior.,

In the discussion of emergence and reductionism we saw that accidental events are sufficient to evoke a higher order in living beings or even life itself, but they are not sufficient to sustain it. As an open system, life stabilizes what would have remained merely accidental without the emergence of order. In the stabilization of the previously accidental, life also sustains itself. Thus, we found that life was partially self-explanatory since to understand its emergence and survival we had to understand the emergent operational principles of the living being. Conversely, the logics of emergence and achievement and the corresponding necessity to comprehend the living entity as a comprehensive entity guarantee that it cannot be understood in terms of physics and chemistry alone.

In short, evolution cannot be caused only by accidental changes, since what is accidental, by definition, lacks order. To explain the order, we must have recourse to an understanding of the order itself. Thus, Polanyi notes that

> I deny that any entirely accidental advantages can ever add up to the evolution of a new set of operational principles, as it is not in their nature to do so.

The argument is brought home more forcefully if we recognize that life is not merely orderly, but it also orders. When life emerged ordering or operational principles emerged. Put another way, life is an organized organizing. It is because it is an organizing that it cannot be explained in terms of its antecedent conditions. If it would, it would merely be organized, and it would be organized by them. As self-organizing it cannot be explained by them.

The question becomes more complex if we consider that there are at least two kinds of emergent results. Life is primarily a set of biotic achievements which are solutions to the problem of living. However, characteristics also emerge which are not operational principles of some type and which secure an adaptive advantage for the living being. The best known example of this is the advantage secured by animals whose colors blend with those of their habitat. Advantages such as this can arise from mutation or random genetic variation and do survive because they secure an advantage for the species which raises the probabilities of surviv.al for the animals having the characteristic. There may also be grey areas where the two types of emergence approach one another. However, there are also cases where they are quite distinct.

Another problem in the theory of evolution is accounting for the emergence of higher levels of organization. Evolution has seen the development of more complexly organized beings. Polanyi tries to explain this through his notion of phylogenetic fields. We were introduced to the notion of fields earlier in considering the development of organisms. Waddington provides a minimal definition of a morphogenetic field.

> We use the word only to mean that throughout a certain mass of developing tissue there is some generally pervasive influence that relates the various parts so that they fit together into an organized pattern.

Instead of there being one organizer which accounts for the emergence of organization, there can be a variety of influences. Within the field there are gradients. These are areas which exhibit more activity than others leading in ontogenesis to developmental changes. In the development of particular organisms, the activity in the morphogenetic fields is the emergence of a series of organizations, understood either as certain structural features in different kinds of cells or as the organic chemicals synthesized by cells, which are the conditions for the emergence of higher organizations. In turn, these higher organizations may lead to the development of conditions for the emergence of still higher organizations. Some of the lower level organizations may remain in the adult animal, being instrumental for physiological functioning. Others emerge and disappear in the process of development. Such, in a highly schematic form, is what Polanyi terms the maturation of the organism.

His thesis is that a similar form of maturation occurs phylogenetically; that is, on the broad scale of evolution itself. We should be able to identify certain phylogenetic fields in which there exist gradients leading to development of species. Polanyi notes that

> It is a process of maturation which differs in the most curious manner from that of ontogenesis; for it is a maturation of the potentialities of ontogenesis.

There are at least three degrees of achievement in biological development distinguishable by their originality. The first is the achievement of a foreseeable end. This is evident in intelligent actions of humans and other animals. It is analogous to physiological functioning. The second is the emergence of new fields which will perform higher organizational functions. This is illustrated in the process of ontogenetic maturation. However, the emergence of operational principles in maturation is itself organized.   There are operational principles of development. In both these cases we have the emergence of something new, but not the emergence of something entirely novel. Phylogenetic emergence is the emergence of entirely new operational principles, or biotic achievements. These achievement; can either occur within a field, in which case they would be the realization of potentialities of the gradient of the field, or they may lead to the emergence of anew phylogenetic field with its own set of potentialities opened and limited by the kind of biotic achievement which emerged. Thus, Polanyi thinks of evolution as a process of fundamental innovations, tending to produce ever higher biotic achievements.

However, he pursues the analogue between ontogenesis and phylogenesis even further. Just as the emergence of higher level fields in the organism is governed by operational principles of development, so is evolution directed by the operations "of an orderly innovating principle." However, a problem arises here. The ordering principle of individual biological development is immanent in the germ plasm. For example, it is currently hypothesized that different segments of DNA are turned on and off at certain periods of development by the products of the organic synthesis they initiate. This is considered a key activity in a very complex system of developmental regulation. The operational principles of future development are embodied, in some sense in the immature organism because it is a member of a species. born of a mature member of the species which has attained the level of development it is moving towards, and which has passed on the operational principles of that development in the germ plasm. However, in evolution there cannot be this influence of higher biological organizations on lower ones leading to their development into the same kind of being as the higher organization because the higher organization has yet to emerge. Its emergence is the key event of evolution. Thus, what is the source of the orderly development? If there are operational principles of evolution, where are they embodied?

Evolution, for Polanyi, occurs primarily in the> germ plasm. If we consider the evolution of man, or anthropogenesis, we can readily see that there is continuity between the germ plasm of the unicellular organism from which a particular man evolved and the germ plasm from which he developed. Anthropogenesis, then, is a maturation of the germ plasm. The germ plasm, as an achievement is, as the ground of development of the individual which it is, a set of potentialities of individual development. Additionally, at any point in the maturation of the germ plasm, it has a set of potentialities for evolving into new kinds of individuals, where the potentialities are fixed by the kind of achievement it is. This should not be difficult to accept, since it is a principle we find em bodied everywhere; that particular kinds of structures, orders, coherencies, are conducive to the emergence, development, maintenance, of particular types of other structures. However, Polany1 goes on to state "that the maturation of the germ plasm 1s guided by the potentialities that are open to it through its possible germination into new individuals," This, presumably, is the basic operational principle governing evolution. Again, he states that "the possibility of' unprecedented achievements guides the maturation of the germ plasm to ever higher evolutionary stages." His understanding of this guidance is extremely subtle, though I think that it is fundamentally wrong. He draws a series of analogies between morphogenetic fields, heuristic fields, and phylogenetic fields. We are already acquainted with morphogenetic and phylogenetic fields. We should now understand what Polanyi means by a heuristic field. Understanding as tacit integration, or comprehension, has been understood as

> … an unformalizable process striving towards an unspecifiable achievement, and is accordingly attributed to the agency of a centre

seeking satisfaction in the light of its own standards.

We are guided by intimations of coherence embodied in our striving to understand. To a large extent the act of understanding brings itself about. This is most evident when we pursue understanding simply for its own satisfaction, as in intellectual games, such as chess. In this instance and in the more general case of understanding as such, we can acknowledge the existence of a heuristic field. In the heuristic field, as in the morphogenetic field, there is a "generally pervasive influence that relates the various parts so that they fit together in an organized pattern." The parts are the subsidiaries upon which we rely for understanding (not all of which will be organized of course). The "generally pervasive influence" is our drive to understand, enticed into further efforts by the anticipation of intelligibility. Just as there are gradients of force in mechanics and gradients in morphogenetic fields which lead to the development of organic structures, so there are gradients within heuristic fields which lead to discoveries. Some questions, images, symbols, formulations, clues and so on are more fruitful than others. The degree of a person's intelligence is partially determined by his ability to recognize and follow these, resulting in increased activity in a portion of the heuristic field.

Now, heuristic fields are definitely finalistic. We are consciously oriented to some end which, in this case, we bring about by ourselves. There is also finalism in morphogenetic fields. For example, by a complex regulatory system using feedback mechanisms certain processes are turned on or off in the organizer. However, in the properly functioning field, the processes are not turned off until a certain phase of development is completed. Also, if there is some variation in the field caused by either external or internal circumstances, different processes may come into play to circumvent the interference and lead to the development of the proper organization.

Thus, there are teleonomic processes in the morphogenetic field striving to bring about the realization of some end, the criteria of which are immanent in the organizer or its equivalent. We meet a structure similar to that encountered in the heuristic field, though the process is neither conscious nor intelligent. But it is finalistic.

However, difficulties emerge if we turn to Polanyi's notion of phylogenetic fields, Here too we may discern gradients of activity which lead to different lines of evolutionary development. We should acknowledge that some biotic achievements are more fruitful than others in that they lead to more complex organic structures. It is tempting to view evolution finalistically as Polanyi does. If we look backwards from man to the emergence of life itself, we cannot help but be awed by the richness of what has developed as well as the incredible manner in which biotic achievements coalesced to develop the human species. However, it is one thing to acknowledge that evolution has led to man, and it is another to claim that evolution was leading to man. And it is still another to claim that evolution was leading to man, y a process in which the germ plasm is "guided by the potentialities that are open to it through its possible germination into new individuals." This implies that the finality of the phylogenetic field is of the same type as that of the morphogenetic field and of the heuristic field. But there are powerful reasons for rejecting this claim.

Let us first acknowledge that in some sense evolution is finalistic. There is a movement immanent in evolution towards the development of more complex organisms. This does not mean that there is not a movement to less complex organisms. There is, but they are generally eliminated. We cannot conceive of such a movement as a development. Conversely, because evolution is a development, it must be conceived finalistically. In the most abstract sense this simply means that the potentiality for organic integrations to be integrated in higher integrations is realized.

However, in this case the possibility of achievement is not guiding the emergence of the achievement, in the sense that morphogenetic fields are self-regulative or in which intelligence is guided by the recognition of the potentiality of discovery. The latter case is clearly teleological since inquiry is purposive. In the former case the sequence of development is not evolving, but is prefigured in the germ plasm, passed on by a mature member of the species. In this case, it is not guided by potentialities~ but by actualities, the norms immanent in the structure at its present stage (where the norms are, for example, that the synthesis of a particular protein will result in its binding to a certain site on the DNA preventing any more synthesis of a certain range of proteins).

To say that the germ plasm is guided by the potentialities open to it is to understand evolution teleologically. The end, or possibility is evoking the means for its own achievement. However, since it does not exist, it cannot do this.

A second objection is that evolution is not as orderly as individual or intellectual development. Accidental configurations can evoke higher orders by being the conditions of them. Likewise, in evolution the accidental configuration of certain conditions can lead to the emergence of higher orders, except in this case some of the conditions for emergence can be highly developed biotic achievements. But their emergence may depend on external as well as internal conditions. Their survival certainly does. Since their survival is instrumental to the emergence of the next higher achievement, accidental processes contribute significantly to evolution. The "operational principles" of evolution need to be understood more in terms of statistical correlations, as in population genetics. However, the strength of Polanyi's analysis is that statistical understanding of evolution must also rely on understanding the emergence of biotic achievements, since different kinds of achievements lead to different probabilities of survival and of emergence of new kinds of beings.

Third. if the germ plasm is guided by its potentialities leading to the emergence of higher integrations, then Polanyi is coming perilously close to affirming that lower level processes constitute higher integrations. However, if emergence is the most strategic event in evolution, then the lower level does not bring about the higher level, as it does in a certain sense in development. Rather, the lower level, simply by being itself, possesses potentialities which are realized by the emergence of higher organizational principles. In its action it may set up the conditions for the emergence, but it does not bring it about by being guided by the possibility of it.

Thus though we must claim that because evolution has led to man that it was leading to man, the finality of this process possesses a far greater degree of chance than that of the morphogenetic or the heuristic field. Evolution is towards a series of possibilities only some of which are realized. While we would claim that individual development failed if it did not give rise to a healthy mature member of the species, we could not claim on the level of biological science that evolution would have failed had man not evolved.

10) CONCLUSION

In this chapter I have been concerned primarily with the object of knowledge, focusing on life. The main clue for understanding life, as for understanding knowledge, is Polanyi’s notion of integration and the logical unspecifiability implied in it. Though Po1anyi does not attempt this in any systematic fashion, there is the possibility of constructing a metaphysics, a central aspect of which would be his theory of hierarchies, which is empirical and testable. This would cut through the current misconception of metaphysics as speculative, or as comprising unverifiable statements.

In addition, we may conclude that life and knowing exhibit similar structures. Rule governed knowing corresponds to machine-like structures in the organism, while more creative achievements correspond to organismic processes. Po1anyi goes so far as to postulate that both kinds of knowing correspond to different neural structures.

We may also conclude that what Polanyi terms the mechanist conception of the object of knowledge is false. Organisms cannot be understood reductively. In addition, the possibility of predicting future events is limited, whether that prediction is conceived in terms of a determinist or a statistical model because evolution exhibits a high degree of creativity. One could just as well try to predict the state of knowledge five hundred years from now.

We should now. return to Polanyi's main argument, that knowledge is personal. The discussion of the next chapter will allow us to integrate the results of all the previous chapters within Polanyi's understanding of personal knowledge.