V - Emergence and Explanation

It is time to take our bearings as this chapter is a transition to the development envisaged earlier that will integrate the explanations of the natural and human sciences into a common model. The first part of the model will be presented at the end of this chapter when we discuss the notion of the thing as a whole and show how it can be applied to living things as structured and open. There is an openness intrinsic to life illustrated via evolution, development and the behavioral cycles at any stage of development. We will understand that openness as the exploitation of the non-systematic.

Teleological explanation leads to the notion of how to understand development. This requires an understanding of evolutionary differentiation and emergence. In turn, this requires an excursus into understanding the non-systematic which provides us with the foundation for understanding a thing as a whole. With this understanding we can round out our notion of explanation by understanding when we have reached a full explanation of the emergent. Analogously, this provides the foundation for understanding judgment as an instance of the virtually unconditioned so we can explain how we can have factual and certain knowledge though we do not have complete knowledge.

On may wonder why we have moved through the topics of the first four chapters to arrive at this technical and apparently a-personal or non-existential chapter. Let us briefly retrace our steps. In the first and second chapters we had two major goals. The first was to understand science as explanatory rather than descriptive. Indeed, the recommendation was to replace description with data within the scientific context. The second was to understand science as factual. This does not mean that science always attains the facts, but that the structure of scientific judgment is of a virtually unconditioned where some of the conditions happen to be fulfilled. A third goal was to understand the broad notion of an existential explanation. This is necessary because they are required in the human sciences where the scientist and the object of science can overlap. There were two major parts. The first was a definition of existential explanation. The second was a schematic overview of how phenomenology and existentialism were implicitly explanatory though they thought they were being descriptive or hermeneutical or both. In the course of the discussion it was demonstrated that a science of consciousness is possible even though one's consciousness is private. This is because the social aspect of experience is established via understanding since all "experience" as a correlate of consciousness is private. So if a science of consciousness is not possible due to privacy, neither is natural science.

Chapter four provided an introduction to meaning and signs and the distinction between meaning and intelligibility. This is key since the human sciences deal with meaning and signs and the biological sciences do not. We must temper the last claim because a number of animals display intelligence and some of this regards rudimentary use of signs. To resolve the extent to which they use signs and participate in a world mediated by meaning demands some philosophical clarification of a model in which this can be understood. This is one step in doing so.

In Chapter Two we discussed that one reason the conditions for judgment may not be fulfilled is that science deals with complex explanations. Not all the relationships are understood and as understanding progresses science is subject to revision in its basic terms and relations. However, the next explanation will be factual in intent and subject to the same provisional acceptance by the scientific community. Now it may be that some of the terms and relations in current theory may survive in the final theory. For example, the fact that within at least one reference frame the earth circles around the sun probably will survive. In other cases the terms may remain the same, but their relationships may change, in which case the specific meaning of the term will change. However the reference of the term in the sense of the entity or relationship to which it refers may remain the same. This is evidence for a heuristic concept. Finally, the whole set could change. This is most likely to be the case in physics dealing with unobservables since the principle of individuation for us in this case is found in the theory which explains the observations determining the referent as individual. This is less the case in the human sciences, botany, and ethnology and so on where the principle of individuation for us is the particular as experienced.

This is possible in physics because of our use of signs. Insight requires images. Whereas initial insights are into the intelligibility immanent in images, the more recondite are into the intelligibility immanent in signs. In the case of signs, there already is an intelligibility for us which may or may not be conceptualized. Using the clearest example, in cases where it is conceptualized, the subsidiary manipulation of signs in trying to understand the undiscovered implications of what we already understand or know exploits the imaginal in conditioning the emergence of insights. Thus there can be a spontaneous attempt to make our concepts consistent with one another. When we are conceiving, we may not be satisfied with our formulation of the insight until it is consistent with what we already understand or know. Once we understand logic, we can recognize that a scientific theory, in its term, needs to be consistent and make that a principle for accepting additions to a paradigm or a theory. This renders greater control of meaning. For example, Galileo accepted as a scientific principle that the mathematical implications of the mathematical relationships discovered and confirmed via experiments and observations were themselves hypotheses that needed to be verified and that we would expect to become verified given the truth of the prior discoveries. Thus, formal relations can suggest plausible hypotheses.

Though numbers may not be particulars themselves, they do provide a means for understanding the interrelationships of particulars as such, whether we want to understand these as things, qualities, measurements, or most generally, relata. It makes no difference mathematically if the particulars are observable or not. Thus, the use of mathematics makes possible the reasonable postulation of unobservable things and events and provides a means for understanding their interrelationships. Moreover, it provides a means for understanding them independently of sensing since we can move beyond the observed data to understanding the relations which explain the data. In some sense the observed data are given. The relations, on the other hand, are discovered and then conceptualized mathematically. They are verified via measurable observations.

The remote possibility of a science of the unimaginable and the reality for us of things and events we cannot in principle experience rests on the cognitional fact that verification in knowledge of facts relies on observation which in turn relies on someone's immediate experience, but that discovery does not. Now, we can have insight into our immediate experience. However, when we have insight into our immediate experience once we live in a world mediated by meaning, it is insight into an experience for which there is a meaningful context. The meaningful context is matched by language and other skills we utilize to understand. It is more common to have an insight into what we imagine. In those cases, it is clear that we would need to confirm that the understanding of the imagined is the same as the understanding of the experienced. Thus, there is an intention of reality in our questioning and understanding, but the reality is not given except as already achieved, or known, and anticipated. This means we are not restricted to reality being empirically given. Instead, we are restricted in knowledge of facts to reality being empirically verified.

The next chapter solidifies the distinction between meaning and intelligibility by understanding it in terms of spontaneity and embodiment. This lays the ground work for understanding that we embody the distinction within ourselves. Thus we live both in a world mediated by meaning that is known explicitly and in situations where some aspects of ourselves and the situation are known implicitly. There are two general cases. We can grasp relations which are intelligible for us but not meaningful. We also can grasp meaning, but not be able to articulate it because we do not have the linguistic or conceptual framework. Thus, our development is rife with underdeveloped insights and interpretations which can be operational but not known. This can be the fertile ground for the psychologist if our behavior becomes dysfunctional. It also means we can live in a world mediated by meaning that we take, or anticipate, to be fully meaningful, though we do not understand all of it.

A similar distinction occurs in performance. Performance has both explicit and implicit elements. The implicit is operational but not attended to. It origins can be explicit performance but in its operation it is not at the focus. Thus, we can have "automatic", or operational, thoughts informing our moods but not attend to them. Making the implicit explicit becomes more than a matter of paying attention. It may mean understanding it and, in the process, understanding ourselves in a new way. The fact that we can have thoughts informing our moods and behavior to which we do not pay attention and where we may have to work to understand their structure accounts for the fact that people who are perfectly reasonable explicitly have behavior they and others cannot understand.

Another goal was to understand the general role of a hermeneutic phenomenology in the human sciences. Meaning, as informing cognitive and free performance, is for us consciously. What people typically take to be experience is the spontaneous givenness of meaningful performance and its meaningful correlates. Thus Kant took experience to be intuition which combined sensitivity with thought. We discovered that hermeneutics fills a role analogous to observation. If the human sciences include human meaning, there needs to be a way to get at what the meaning is in the concrete context of human living. Hermeneutics and semiotics can do this. Then it becomes a matter of explaining it.

Finally, we distinguished between a relatively naïve notion of knowing and a more critical notion. The former makes it much more difficult to understand and appreciate the role of understanding and meaning in human living since meaning and intelligibility are projected as being in the object without recognizing their source for us in understanding. Reality is given "immediately" without distinguishing intelligibility as in some sense constitutive of it. The latter notion, as understanding intelligibility as intrinsic to being, has little difficulty in recognizing that most of human living regards intangibles which provide structures for behavior and intersubjectivity just as inevitable in their way and within their own context as the law of gravity. It also recognizes a gap between life as lived and life as explained. Science deals with the latter, but cannot do so without taking the former into account. A philosophy of science that devalues explanation in the emphasis of lived experience risks losing both in its theories and impact. Likewise, a human science that focuses on the abstract at the expense of the concrete risks becoming ungrounded and trivial. Rather explanation needs to be understood within the context of lived experience as transcending, informing and, hence, transforming it. While individuals will experience the transformations to various degrees depending on their differentiations of consciousness and areas of specialization, socially it informs and transforms social structures, institutions and interactions with some independence of how anybody understands it. Hence, it seems that a philosophically critical sociology would provide some understanding of and, perhaps, guidance to, social development.

Through the course of these discussions we also have focused on insight as direct, in its roles in conceptualization and judgment, and in the development of skills. Though we have dealt indirectly with its role in a theory of knowledge and in epistemology as we needed in providing the required propaedeutic for the model to come, we also have indicated its constitutive and integrative functions in development. These extend from the emergence of refined sensitivity, language, and the mastery of complex skills. An adequate scientific model of mind needs to account for these roles.

The need to explain this flexibility and impact of intelligence provides a convenient segue to answering the question posed above. Why have we moved through the topics of the first four chapters to arrive at this technical and apparently a-personal or non-existential chapter? It is more than the fact that to explain lived experience we need to bring in other sciences as well as attend to and understand the experience itself. It is that if we are to have an integrative model there must be some way to explain the correspondences and relations between the elements and relations of lived experience and the elements and relationships explored in other sciences. So the topics developed here, though done in an a-personal context, will be seen to have significant implications in the development of a model that can explain the personal, its psychological and biological relations and its objectivity.

The Issue of Teleological Explanation

Explanations, as meaningful, consist of terms and relations. What is explained, the explanans, is explained by situating it within a set of terms and relations. If the terms regard things that exist, or aspects of things, or events, and the relations regard how these are ordered, then explanations have existential import. Traditionally, the discovery of why something is the way it is, is the discovery of its causes. In Aristotelian terms, an explanation of the formal cause would be the set of terms and relations referring to what is intrinsic to the explanans, or what it is. The material cause is the set of terms and relations which are in turn organized by or within the explanans. The efficient cause is explained via the terms and relations referring to what brings the explanans into existence. The final cause is explained by understanding that to which the explanans leads and for which it exists. Traditionally, to understand something teleologically is to understand its final cause. Understanding the more parsimonious scientific notion of teleology will provide a convenient context for introducing the key aspects of our model for understanding mind and behavior.

In modern philosophy of science, the only type of causality which is widely accepted is efficient causality. Efficient causality typically has a strict asymmetric temporal component. The causal relations precede the explanans. The present is explained in terms of the past. This is true even of fully reversible processes. Though the past situation could be replicated if the situation it led to was fully reversed, there still is a sequencing of events as predecessors and successors. However, most situations are not fully reversible, so the prospect of the past being fully replicated is virtually impossible. We will discuss this further when we discuss entropy below.

Teleological explanation, though, would explain present function in terms of future effect. For example, the gamete is the way it is so that it will grow into an adult of its species. To some extent, the adult form explains that which precedes it. In goal directed behavior the same explanatory relation of future to past obtains. Present performance is understood in terms of the goal of the organism, or in terms of future achievement. One could counter that in physics and chemistry present events are understood in relation to future events. In fact, any explanation of efficient causality is relating one event to another which follows it. However, these are simply temporal relations. The second term of the relation does not explain the occurrence of the first, rather the first explains the occurrence of the second. But then is it the case that in teleological explanations we are trying to explain what does exist, things and events in the present, in terms of what does not exist, things and events in the future? Understanding evolutionary differentiation within biological systems and the form of emergence of greater from lesser complexity leads to the resolution of this paradox. Teleological systems have been caused by past events, but their internal structure must be understood by relating present form to probable future performance.

Evolutionary Differentiation

One of the difficulties in understanding teleological explanations stems from the evolutionary stage of the organisms that we study. At the higher end of the evolutionary tree we have animals that exhibit conscious, goal setting behavior. It is extremely difficult to determine the bearing that the hereditary endowment and the corresponding biochemical substrate has on the development of these complex acts. At the lower end are simpler organisms whose behavior is more adequately explained biochemically. Some movements are triggered by the external presence of types of chemicals, and the movement itself exploits the potentialities of physical and chemical laws. Were it not for the fact that the organism unifies these events in complex sequences, the physical and chemical explanations may seem to be adequate. If these acts are not completely determined by biochemical relations, how do they emerge? How are we to explain them? Insofar as they are conditioned by biochemicals, how did systems evolve where events that are to occur years from now are presaged in the gametical structure?

These questions are answered philosophically through a general theory of emergence which accounts for the becoming of greater from lesser complexity. The last question concerns the emergence of the complex timing and sequencing of events in development since development also entails the emergence of greater from lesser complexity.

Part of the answer involves understanding evolutionary differentiation. Homologous structures are those which perform similar functions in different ways in different forms of life. Life is self-sustaining. It keeps itself in existence by assembling some of the conditions for its existence. It is also auto-organized, but not always auto-organizing. We will discuss these distinctions below when we compare them to self-organized and self-organizing. As auto-organized, some of the conditions which it assembles are developed internally in the form of biochemicals or biological and behavioral structures or systems. This is manifest prominently in another homologue, reproduction. If we define development as a change in state in living systems to a more complex state permitting more variable and flexible activity, then development is a homologue exhibited by most life. Different types of development evolved. Movement is also a characteristic of most forms. Keeping these general homologues in mind, one can study the various forms of life and see how they are realized in the different structures.

In standard evolutionary theory a species gains a characteristic or capability that provides a selective advantage. This increases the probability that the organism will survival to reproduce and pass the advantage to the next generation. Though the advance is generally understood in terms of the species, evolution proceeds in individuals. While in development, it is the same unity that changes over the life cycle, in evolution, it is generations of unities. But it is theoretically possible to trace the conditions for most of the current characteristics and capabilities back to their origins in individuals in earlier generations.

Evolution of a characteristic occurs within a pre-existent sequence and is an elaboration of it. Increasing differentiation and complexity can lead to longer sequences of events. Just as in embryonic development there is originally one cell which through multiple divisions gives rise to a highly differentiated complex unity, there is an evolutionary elaboration of functions which differentiates them from within, so that the unity of function can be retained through the evolution of the species. Since it is the same function, the new features are understood in terms of the overall function. If we consider one of the basic homologues such as movement we can see how the increasing complexity of movement and the differentiation of functions required to support it, are understood in terms of the operation of moving. Since the increasing differentiation is within the set of operations, and since it survives insofar as it makes the set of operations more effective in contributing to the survival of the species, it should find its explanation in terms of the set of operations.

Since the differentiation occurs within a pre-existent "whole", the events are organized in terms of their future consequences and appear goal directed. Since some events precede and condition others, the earlier events need to be understood in terms of their consequences. In these instances, then, "teleological" explanation approximates the explanations typical of physics and chemistry. The present state was caused by past evolutionary activity and consists primarily in the more elaborate timing and sequencing of events with a relatively predictable result or set of results. While events are understood in terms of their consequences, their remote causes are antecedent events of the same type as their consequences, the evolutionary advantageous activities of their ancestors which led to their survival and subsequent reproduction of offspring.

Evolutionary differentiation accounts for the appearance of purpose, but it permits the explanation of the current state of an organism without reference to it. On the other hand, in development we can understand the current state in terms of the probable future outcomes. This is not to understand the efficient cause in terms of the future (or to understand the current state in terms of a final cause). Rather, it is to understand the formal cause of development, that is, what development is. Most generally it involves current states which in some sense lead to other states where understanding how that happens involves an understanding of both present and future states.

If we extend the principle of evolutionary differentiation to the organism as a whole, we can see that while functions and operations get differentiated, they are differentiated within the succession of organisms as wholes. This is significant for understanding philosophical issues such as the traditional mind-body relationship. Insofar as there is a difference, it is one that arises within a whole

We have a secondary issue that arises in understanding organic processes. There are parts to processes such as biochemicals that function within the process. This notion of function is normative only in the sense that the function is part of a biological organization's operations. Either "X functions" within the operation or it does not.

This definition, then, provides for biological explanation which is non-teleological since there can be an organization of conditions for an act or performance, where the organization is not goal oriented or goal directed. It is possible, also, to conceive of strictly teleological systems where there are explicit goals as functional. If so then functional explanations would seem to be the broadest category of biological explanations.

Behavior emerges which is unquestionably goal oriented such as hunting and mating behavior and the human apprehension and actualization of values. The possibility of these behaviors rests on the types of processes which have evolved. In these instances we can understand something as goal oriented without having the goal be the cause of the behavior. Rather, the goal as part of the behavioral complex has a function as being in some sense "for" the organism as a desire or need, for example.

Evolutionary differentiation, then, is within "unities" or wholes or modules. The addition of functions which support an organism's activities emerges from pre-existent processes. The differentiation within wholes occurs ultimately within the "broadest" whole which is the organism itself.

This account of evolutionary differentiation has shown that not all biological explanations are teleological. Some are merely functional. Biological functions may have their source in prior evolution. Though they need to be understood in terms of their consequents, their consequents are not the cause of their existence. However, past events of the same kind as their consequents can be causes of their existence, since these events, such as operations of their ancestors, contributed to their ancestors' survival and ability to reproduce.

Evolutionary differentiation of functions within wholes as we have discussed it is dependent on the emergence of greater from lesser complexity. While we have shown that not all biological explanations are teleological, we have done so with recourse to a notion of emergence which we now need to explain. To prepare for this we must discuss complexity theory as it relates to biological systems and the causal role of nonsystematic processes.

Systems and Hierarchical Organization

Rather than being in a reductive or a hierarchical relation to one another, the sciences are complementary to one another. Fundamentally, reduction models the sciences as a series of levels of explanation where the lower level ultimately explains the higher. The higher level, then, is not really higher but a synopsis, simplification or abstraction of the lower level that would disappear if we had the lowest level of explanation delineated and preferred to go through the detail of dis-integrating the higher levels in terms of the lowest. Alternatives to reduction include considering the sciences as a series of levels of integration or organization where the higher level cannot be reduced to the lower because it organizes it in some sense. In this characterization one may notice that reduction corresponds to analysis and the notion of higher organizations of lower levels of entities or parts corresponds to synthesis. However, both of these, as trading on the spatial metaphor of levels, tends to assume that a whole is something that can be disaggregated or built. While this may be true of things like houses it is not true of organisms. There is a complementary notion that the sciences stand in relation to one another as organizer/organized or as of lower to higher viewpoints as in the case of some of mathematics. In the case of the organism the sciences do not stand in the relations analogous to those of organizer and organized. Rather they are complementary to one another in understanding different aspects of a single thing. Philosophy, insofar as it is scientific, would have a complementary role.

Rather than being assembled like a machine or a house, evolution and development exploit emergence of complexity within wholes. We will see that in the emergence of life as in emergence in general, the emergent organization or "whole" in the broadest sense, is part of the cause of its own existence. Development proceeds via increasing differentiation followed by the emergence of new integrations. In some cases the differentiation is organic as in the development of the brain where neural areas are formed. In others it is operational where existing organic structures do not grow, but enable innovative performances.

There is a corresponding error where we consider the sciences as regarding different kinds of things. Thus, physics deals with subatomic particles, chemistry with chemicals and so on. Understanding how there can be a physics of the organism which is different from the physics of subatomic particles requires a switch from the metaphorical notion of levels of organization to the explanatory notion of contexts. But to get there and to the more general model of the operational situation, we need to understand emergence, the non-systematic and its role in structures and a new notion of a whole which incorporates structuralism and post structuralism into a single view. The model of complexity that will emerge from this discussion will be metrical and holistic rather than hierarchical.

Hierarchies

Hierarchical organizations are typically explained in the context of systems theory. We will pursue that course here to lay out a simple model of emergence and the non-systematic. By developing a non-systematic notion of structure, a whole and a thing we will be able to develop a more sophisticated model that is compatible with the complexity and flexibility of organism's operations, acts and performances. The latter will allow us to understand how metaphor can insinuate itself in non-productive ways into explanatory accounts. Our illustration will center on transitioning from understanding complexity in terms of levels, to understanding it in terms of contexts. The former can lead to non-holistic notions of things, which, we will see, misses the whole point of what the complexity of life and consciousness is all about.

Hierarchical organizations exhibit levels of organization where higher levels organize lower levels. We find this in everyday life. For example, in language words are integrations of letters that in turn are integrated in sentences according to grammatical and semantic rules and precepts. In games, such as cards or chess, the game pieces are organizations in their own right which are organized within the game by the rules of the game and the strategy of the players. There is the hierarchical organization of the corporation where workers are organized into departments which are organized at a higher level, such as a division, which in turn is organized by the CEO and the

Board of Directors. In living beings we find cells organized into organs which are organized into systems, such as the digestive system, which are organized in terms of the operations and acts of the organism, such as hunting, reproduction and so on.

The abstract schema is fairly simple. Let us consider a hierarchical organization O. On the lowest level of organization, A,B, C, and D are related to perform function F1. E, F, and G perform F2. H, I, and J perform F3. The repetitive performance of F1, F2 and F3 constitute O. In this example there are three levels of organization. However, it is easy to see that higher levels are possible through the iteration of our scheme starting with organizations on the level of O.

The specialization of systems to perform functions which are in turn organized permitted the modularization of functions. Modularization not only occurs on the same level, but exists between levels. This is the basis for equifinality and equipotentiality. In equifinality we find the same purpose being achieved by multiple means. For example, in the above schema it makes no difference in the occurrence of O if F1 is achieved through A, B, C and D or through X, Y and Z. The important thing is that F1 occurs. Within certain limits, then, in many structures the higher level of organization is indifferent to the manner in which the lower level achieves its function. The notion that similar higher functions can be achieved with variable lower level conditions is the foundation of functionalism.

Just as higher level organizations can exist given a variety of lower level structures, so can lower level structures be parts of more than one kind of higher level organization. Corresponding to equifinality is equipotentiality. For example, the human hand can be used for a variety of tasks, and in human action the same means can be used for multiple ends.

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Considering equipotentiality further, we can see that the emergence of a higher level of organization is the emergence of greater potentialities for the system in which it emerges, for it provides the system with new capabilities for relating to other things and systems -- particularly, to those on its own level of organization.

The lower level of organization functions as conditions of the higher level. As what is organized it is a material condition. However, a series of lower level events can lead to other lower level organizations which in turn become organized by a higher level. In this case they are efficient conditions of the higher level of organization. An explanation of the higher level would necessarily be in terms of its conditions, or the lower level. However, is the lower level alone sufficient to explain the higher level? Can biological functions be explained fully in terms of their conditions? If they cannot, then there exist different levels of explanation corresponding to levels of organization.

The existence of equifinality and equipotentiality on each level of organization points toward a degree of independence of one level from another. If different lower level configurations can lead to similar higher level structures, then the higher level must have some independence of the lower. Distinct structural types do exist on higher levels of organization. Feedback mechanisms exploit common self-regulatory principles, yet take a variety of forms. We also find homologous biological structures at particular levels of complexity, including homologous behavioral systems. This is the key insight in functionalism. However, this does not establish that the higher level cannot be explained completely in terms of the lower, since it is possible that similar principles are operative on both levels, though different types of lower level configurations contribute to similar higher level structural types.

The crucial link in the argument establishing that higher levels of organization cannot be explained entirely through the principles which explain lower level entities and events lies in the understanding of emergence.

Nonsystematic Causes and Emergence

By understanding what has emerged, we are at an advantage over those who wish to predict the future. We can work backwards from the present structure to its cause. In the case of life, however, this has proven extremely difficult due to the gap between the types of structures which preceded life and life itself. Life is auto-organizing, reproductive (self- replicating) and assembles the conditions for its own existence. Once the process of living commences, then, living beings are a primary cause of their survival and other living beings were the cause of their coming into existence. Obviously, the emergence of life could not rely upon pre- existent life as its cause; hence, the difficulty of the problem.

What is the cause of life? The nature of the particular events in the origin of life is a scientific question. Philosophically, however, the structure of the emergence of life is similar to that of the emergence of any more complex organization from a less complex structure or situation.

The source of emergence can be found in two places only, in the conditions preceding the emergence and in the emergent itself. In the emergence of life, and in emergence in general, it is either a set of nonsystematic processes, or the nonsystematic results of a set of systematic processes, which provide the conditions for the emergence of organization. In the origin of life the former is the case. In the evolution of life and development the latter plays a key role. If life is a more complex organization than that which preceded it, then it must relate previously unrelated structures, events or systems. Thus, it seems that the prior nonsystematic situation alone is not sufficient to explain the coming-to-be of a system, since all the relations which organize the elements into a system are not operative in the non-systematic situation. If they were, then the non-systematic situation would be a systematic situation which "causes" life, and life would not be a new type of organization. How does system emerge from the non-systematic? How can the nonsystematic situation be causal?

In a nonsystematic process events display a statistical independence of one another. Put simply, an event is independent of another to the extent that the occurrence of event A does not influence or cause the occurrence of event B. If A and B were related systematically, then, if nothing intervened, the occurrence of A would always be followed by that of B.

There are three points we should keep in mind concerning statistical independence and non-systematic processes. First, the affirmation of randomness is compatible with the notion that events have determinate causes. This is easiest to see if we accept the Laplacian assumption 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.

Suppose that at the time of our first measurement they were in different places, they had followed different paths, and they had 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. Then any law concerning their histories would not explain everything about them. This follows because laws are universal. Thus, there is a nonsystematic element given even the Laplacian assumption. The lack of system can be of two kinds. It may concern the particular event, and then it is an accident. Or it may concern the set of events. In the latter case the events exhibit statistical independence. This analysis provides for the possibility of a set of determinate collisions of gas molecules with the overall result approximating a random sample. That is, there is no law or set of laws which governs the occurrence of the set of collisions.

Second, we should not confuse nonsystematic with complete disorder. Though there may be no set of relations which fully explains the existence of a situation, there are relations occurring in the situation. In short, nonsystematic processes have positive results. The conditions are assembled for the next situation. Because the nonsystematic process is not completely disordered, it can be a cause of future processes and situations.

Third, the existence of independence in a situation is that situation's potency for the emergence of greater organization. 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 simple model discussed above, 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 relations which do not concern the mechanics of these particles. Such a relation 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. Likewise, the relations governing these things may give rise to other nonsystematic situations. The possibility of another type of organization is open. Since this possibility is recurrent, there can be a series of more complex types of organizations and things reflected in additional complexity within and among things.

We noted that it is not possible for a situation to be completely non-systematic. If it were, it would be nothing, for there would be no relations. Even a random distribution would be a distribution of something. Each situation embodies relations which bias the distribution of events or their frequencies. Statistical laws regard the sets of situations, or the sets of histories. The fact that a particular situation does not meet the statistical norm does not invalidate the statistical theory. In fact, it confirms it, since the statistics of each situation should form distributions within a range.

Statistical relations, then, are general. We can use them to infer the state of the population based on a sample, but they do not take into account all the details, or possibilities for the population. Thus, the statistics are themselves accurate within a particular margin of error, which itself is a statistical frequency. Not only does this tell us something about the nature of statistical laws, but it also gives us a clue about the world. The incompleteness of our explanations does not reveal a poverty of theory and abstraction, but rather the potentiality of states to be other than they are.

This potentiality is of two types. There may be a change of state where we explain a different state in terms of the same relations. An example would be two distributions of gas molecules in a container. Or a more organized state may follow, in which case we may be dealing with different kinds of systems and things, and in turn, new kinds of relations. This is the case if we have the emergence of greater complexity.

Living beings possess many nonsystematic processes. In fact, we will see that biological and psychological structures' flexibility rests on their nonsystematic nature. However, they are usually considered more remarkable for their high degree of organization.

Though it lives in an environment on which it must rely for its existence, a living being exhibits an independence of the environment by assembling some of the conditions for its own existence, by exhibiting self-organization and by being reproductive. The emergence of life, then, is the emergence of a system which is largely a self-sustaining, self-organizing, reproductive system. Its self-referential nature implies that coincidental with its coming into being is its maintenance of itself in being. If a living being relies on itself for its own existence, it is difficult to understand how it can be explained fully by the principles which explain the events which preceded it. However, if it cannot be explained completely in terms of its antecedents, it must be partially explained by itself. This means that to some degree life must be self-causing in its origin. But how does that which does not exist bring itself into existence? Attempts to resolve the question of emergence have failed to bridge this gap. Most proponents of emergence have posited some form of alogical "leap" from one level or organization to another. In the face of an inadequate explanation of emergence, reductionists have held to the argument that a fully explanatory physics and chemistry will eventually solve the mystery.

A first clue is that synthesis of chemicals spontaneously occurs. This is a type of emergence, though it alone is insufficient to explain life. The mystery can be solved partially if we advert to cyclic processes in nature. Lonergan has termed these schemes of recurrence. Unlike the independent strings of events outlined in the discussion of non-systematic processes, schemes of recurrence are recurrent cycles of events. Piaget's theory of operations embodies the notion of reversible operations which make it possible to return to the initial situation. Operations, then, can form interlocking sets of schemes of recurrence. On a broader scale we have the life cycle with its complex sets of sub-cycles.

The basic structure is that A causes B which causes C which causes D which causes A. If emergence were of a scheme of recurrence of this simple, abstract structure, then, under appropriate conditions, all that would be necessary is for A to occur. If sets of nonsystematic processes converged to produce A, then the scheme would unfold. Other things being equal, it would continue to operate, though the situation which gave rise to it eventually passed. Thus, self-sustaining entities do not cause themselves in the sense that they assemble the conditions for their emergence. But when those conditions are assembled, they become themselves. This possibility of becoming a self-sustaining entity is based on the type of structure which emerges, one which embodies schemes of recurrence. Thus, a virus, like the tobacco virus, can spontaneously form if the right conditions are present.

However, the fact that a process is cyclic does not mean that it is self-sustaining. It simply means that other things being equal, there will be recurrent types of events. A system sustains itself to the extent that it handles the effects of outer influences as well as the modifications within itself. To be self-sustaining, it must be self-organizing. Though living things are in relation to other things and events which trigger key events in their life cycle, there is also a set of internal events which are related to one another and which support activities. The change of internal state permits the assimilation of, or accommodation to, external things and events. These changes are regulated by the living system. Thus, the tobacco virus is auto-assembling, but not auto-organizing. Given the appropriate mixture, or conditions, the tobacco virus spontaneously forms. But it does not develop and cannot reproduce unless it links into the genetic machinery, or sets of schemes of recurrence, of a living entity. It does so by penetrating the cells of the tobacco plant.[1]

In the emergence of life, the most basic processes were the metabolic processes. They transformed the chemical environment into the organism's building blocks and are a primitive instance of a whole assembling the conditions for its own existence.

Conceptually, it is a relatively small step from a system assembling some of the conditions for its own existence and growth to a system duplicating itself if we think of duplication as the assembly of some of the conditions for its existence. In fact, it is an extremely complex process. Von Neumann has proven that a self-replicating system must be composed of at least 220 different

[1] (p. 116, Noble Laureates Anthology)

parts. [2] In nature the smallest reproductive system has over a thousand. However, in replication we have a recurrent process which is independent of its originating conditions. Within the living system it is part of a larger whole and receives many of its conditions from other systems. It is possible to conceive of a non-living self-replicating system using the strategy employed by DNA where templates can produce their complements, which in turn produce copies of the original template. One of the hypotheses for the emergence of life suggests that an independent self-replicating systems merged with independent metabolic systems. It is also possible that self-replication emerged as a specialization of metabolic functions.

The notion of self-replication is a systematic approach. We will see later that self-replication is not necessary for reproduction. Rather a sustainable separable aggregate is sufficient.

In evolution, once the metabolic and reproductive bases were laid, changes in the regulation of self-transformation took the lead in differentiating species. Essentially, this is the regulation of the life cycle. The evolutionary "strategy" was for systems which support key activities to become differentiated from one another. This differentiation was possible due to the emergence of greater complexity. For example, the reproductive, metabolic and motor functions became differentiated within the cell. The development of a nucleus in the cell provided a more complex and more specialized structure. As the cell membrane provided boundary conditions within which the cell could perform its functions, the nucleic membrane provides the same function within the cell. Not only does this secure advantages in the life cycle, it also provides a greater flexibility for evolutionary innovation since evolutionary changes can occur independently of one

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[2] Von Neumann

another within the systems within ranges that can be assimilated or accommodated to by the other systems. A similar process occurred with groups of cells. We have the unity of the cells as one being with the consequent evolution of independent systems of cells to perform key functions. We can consider these systems as having, or as being, operational centers with some degree of autonomy with respect to other systems. Ironically, as these systems became more autonomous from one another, they also became subject to more regulation, as systems evolved to coordinate the activities of the systems. The same process has been reiterated with respect to those systems. A case in point is the evolution of the nervous system. As muscular groups became increasingly differentiated from one another, they also became more coordinated through the evolution of the nervous system. The nervous system itself was subject to the same general evolutionary principle as neural centers evolved to support the various senses and movement.

However, we need to keep in mind that the differentiation of quasi independent systems has occurred within unities. Thus, as "higher level" controls have emerged, the types of central operations for coordinating the whole has changed. For example what was once coordinated on a cellularly is now coordinated neurally. This does not mean that cellular regulation does not occur. But it does mean that this regulation is not what controls the overall activity of the being. In short, acts evolve, and the types of acts that living beings perform and the systems that support them define what that being is: the more diverse the activity, the more complex the organism.

With the emergence of greater complexity and of different kinds of organic activities and acts different kinds of things and relations emerged. As embodying schemes of recurrence, these can become independent of their originating conditions. As self sustaining and self organizing schemes, they are part of the cause of their existence. Insofar as they cause their own existence, they cannot be explained in terms of their conditions or antecedents alone. In turn, this means that the corresponding sciences cannot be reduced to other sciences. Chemistry, for example, can explain some of the conditions for biological organizations, but it does not tell us what those organizations are or how they emerged and evolved. We should not expect it to, for as self-replicating, living things introduced a much more highly organized, self sustaining set of causes than those studied by physics and chemistry. Living systems employ schemes of recurrence which are themselves principles of organization which must be invoked to explain their own existence.

Evolution

Though we have a general view of how living systems emerged, how do they evolve? The particular problem is that our analysis has focused on the emergence of the systematic, where the emergence required the pre-existence of a nonsystematic situation. How can a nonsystematic situation arise in a complex self-organizing system?

The emergence of self-modifying complex modular systems profoundly altered the world situation. In addition to beings which are at most related to their antecedents and consequents in complex causal chains, beings emerged which are related to themselves. While living beings are highly systematic and employ elaborate control mechanisms, in their internal relations it is possible for situations to emerge which are nonsystematic and which in turn provide the potentiality for developmental and evolutionary advances. The emergence of, and response to, these internal situations is an evolutionary force just as the adaptivity to environmental challenges is. This is in contrast to the common view that environmental forces and the randomness inherent in the gene pool are the primary sources of evolutionary change.

George Gaylord Simpson succinctly summarizes some main points of modern evolutionary theory in the following passage from The Meaning of Evolution.

> The evolutionary materials involved in this complex process are the genetic systems existing in the populations and the mutations arising in these. The interacting forces producing evolutionary change from these materials are their shuffling in the process of reproduction, the incidence of mutations (their nature and rate) and natural selection)[3]

Natural selection is defined as differential reproduction where the evolutionary changes which survive are those which confer a reproductive advantage. To be evolutionary, changes must be passed from one generation to another. This means that they must be embodied in the genetic code of individual organisms or, more generally and precisely, the gene pool of the population.

Evolutionary change, then, requires changes in a population's gene pool. The source of new genes is mutation. Mutations occur randomly in all organisms, and their incidence can increase depending on environmental circumstances. The gene pool can also contract if part of a population becomes isolated from another part, or if a significant part of the population cannot adapt to environmental change, for example. Different kinds of structures emerge due to the variations in particular genotypes caused by sexual reproduction and by the type and rate of mutations. Their survival is explained through the probabilities of their surviving to the point where the organisms can reproduce and pass on the characteristic. The primary sources of randomness, then, which account for the changes in the gene pool, are variation and mutation. Both are nonsystematic. As such they may provide conditions for emergence.

The potential for variety on the genetic level is far greater than its expression. Consider the case of a species with ten thousand genes. Suppose one-tenth of them are heterozygous (i.e., there is a dominant and a recessive gene for the same characteristic). The number of possible combinations on this level alone is 2*1000. Let us take this analysis beyond the level of the genotype. If we consider a complex modular system the degree of potential variability is greater. Not only do we have the possibilities for combinations on the genetic level, but each of these combinations introduces variability into the structures on subsequent organization. Variations in structure can lead to variations in the interactions among structures. This possibility is recurrent as greater complexity emerges or develops.

If we consider the development of systems, the variability becomes still greater, since the development of more complex organizations depends on the actions of antecedent and less complex organizations which may either subsist or pass away in the course of development. Modifications of these can affect the later organization. This implies that genes do not function as the sole operators throughout development and the subsequent life cycle. If they do not, and if the

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[3] Simpson

characteristics of an organism are the relations it exhibits in its life cycle, then genes do not uniquely determine all organization. Indeed, if this analysis of emergence is correct, then a major role of genes is to provide the conditions for the emergence of more complex organizations in development and to sustain physiological functions.

If we look at the synthesis of proteins this seems to be the case. The combinations of the four nucleic acids yield about 24 amino acids which are then synthesized into thousands of different proteins. DNA plays a role in this process, but it does not account for the final organization by itself. The proteins can be combined in different ways to yield different structures, for example. These combinations are caused only remotely by DNA, just as the organization of a house is caused remotely by the brick manufacturer. In Aristotelian terms, DNA is a material cause of organizations.

Given the magnitude of possible variations, it is amazing that development proceeds in an orderly manner giving rise to similar individuals. This is evidence for a remarkably flexible system of control of the life cycle. However, despite this level of control, evolution proceeds. Indeed, the more remarkable evolutionary feats are the emergence of types of control. How does this occur?

A Technological Analogy

From our earlier discussion of emergence we know that the institution of a more complex and different organization requires the convergence of the elements which initiate it. That discussion focused on the simple model of nonsystematic processes converging to provide the elements for the initiation of a scheme of recurrence. Once organisms are in existence, however, we are faced with sets of systematic processes and the question of their giving rise to more complex organizations. We know that variability is introduced into the gene pool through mutations. But we also know that the speed of much of evolution cannot be explained given the known rates of mutation. We also know that variability is introduced in the randomness of bi-sexual reproduction. Yet is one thing to have variations in the chromosomes and another to have these variations lead to the emergence of new organizations and, in the long run, to new species. To understand the general structure of the emergence of organization in complex systems, let us consider a fully systematic structure, a properly functioning computer program. Computer programs are written in three basic types of languages: machine, assembly and applications languages. These languages are hierarchically ordered. Machine language is the most basic, written in the 1's and 0's of binary arithmetic. Applications languages are most like natural languages. Mathematical operations can be represented by common mathematical symbols and natural language commands may be used (e.g., PERFORM, GO TO). Assembler programs translate the application languages into machine languages.

The possibility of automating logical and mathematical operations rests on technological advances and the existence of a logical method which can be represented and manipulated mechanically. Boolean algebra is a method for deriving logical proofs developed by George Boole in the late nineteenth century. Its salient feature is the use of 1's and 0's to represent logical truth and falsity. Since electrical switches can be either on or off, an electrical system can be used to represent logical operations in Boolean algebra and numeric operations in binary arithmetic. A computer program, then, can be understood as a logical system. Since it may branch to various routines depending on its inputs or the results of its processing, and since it may also generate complete or partial programs, it can be considered as a self- modifying logical system.

As a logical system, the computer program is completely rule driven. This consistency is the ground of the computer's reliability. In a properly functioning program, predictable results are generated given the parameters of the input, where the results match the purpose for which the program was written. Theoretically, all the results are predictable because we are dealing with a rule- driven system. Practically, however, the situation is quite different, since we do not always foresee the ways in which the different parts of the system may interact. This is especially evident when a program has "bugs" and does not work as intended. These "bugs" may be of two general types. The first is violation of syntax or rules forbidding certain operations (e.g. trying to divide by zero or trying to multiply alphabetic characters). The second results from "logical" errors. The use of "logical" here refers to the order of processing. Hence, the processing may be logical in the sense that it is logically valid, but it may be "illogical" in the sense that it does not yield the results desired. A common error resulting from bad logic in this more general sense is the endless loop. The program branches to a set of operations which do not branch to another set and which have no instructions to stop processing. More commonly, things simply do not come out as intended. If too much is produced, then certain operations must either be eliminated or isolated from other operations. If too little is produced, operations must be added, or logical errors which prematurely stop processing must be eliminated.

The proper development of a computer program proceeds in a direction opposite to the evolution of greater complexity in nature. The program is defined in terms of the purpose of the program. That purpose is realized by using the elements immanent in the machine's design, its operating system, and the programming languages. The design is "top- down". In nature, the design is "bottom-up." Evolution does not proceed in terms of purpose -- though purposive behavior has evolved and proven to be advantageous. But in the development of the program, when "bugs" exist and the purpose is not being realized, we are in a situation analogous in two ways to those which I think recur in nature.

First, we have the emergence of unforeseen results from the interaction of fully systematic processes. Whereas in the discussion of the emergence of life we found nonsystematic processes yielding the conditions for the emergence of system, now we have systematic processes yielding results which are nonsystematic with respect to the system as a whole. In other words, there is no organization which integrates the results. Some of these results may be benign. Others may cause the system to stop functioning. Others may cause a radical change in the system.

It is this feature, a lack of system, which permits computers to be interactive. For example, a writer can use a word processor in a variety of ways since the system does not limit what can be written. The computer enables the writing of a number of texts. Second, the emergence of results which are nonsystematic can present a challenge to the programmer. The program may need to be altered to yield the organization required. The organism is faced with a similar challenge. Sometimes that challenge is met by assimilating the change into an operative organization. Other times that challenge must be met by the emergence of a new organization.

The Evolution of More Complex New Organizations

A new organization is a new scheme of recurrence or a new set of schemes. As noted previously, it is independent of its antecedents due to its circularity, which makes it partially self-dependent. When a more complex organization arises within a complex structure, the source of its elements may be found in the results of the prior interactions of the sub-structures. Though these structures may themselves be fully systematic, their interaction may not be, or the results of their activities may not be. Thus, the path is open for the emergence of a scheme of recurrence which integrates the results, or the activities through the integration of the results. To be evolutionary, this new organization, or the potentiality for its emergence, must be passed from generation to generation. There are a few ways in which this may happen according to current evolutionary theory.

First, there is a probability that the genetic combination will recur within the gene pool causing future generations to possess the organization just as the first individuals did.

Second, the new type of organization may yield an adaptive advantage. In turn this confers a reproductive advantage on the individuals, increasing the likelihood of offspring with the same types of organization.

Third, the organization may lead to the sexual isolation if its carriers. In this instance, a group in the population may move into a new environmental niche as in the movement of the lemurs into the trees and of aquatic life onto land. They would reproduce only with those in their own proximity.

If we extend this last point, we can see that some instances of emergence can be self-isolating. Members of a population become isolated from other members due to the organization which has emerged and the capabilities it confers on its members.

Finally, by combining the following three points, we have a model for evolutionary change where the cause of evolutionary "innovation" is life itself.

1) A diverse pool
2) Nonsystematic situations resulting from the systematic operation of complex, modular systems inviting the emergence of new, more complex organizations
3) The self-isolating nature of some of these organizations.

The advantage of discussing emergence in terms of systems theory is that we could show that a set of systematic processes could be non-systematic. That is, each particular event can be explained as an outcome of a process, but the set could not. The set can result from a set of unrelated processes. At this point we will expand the discussion to understand the openness of structures by providing a more comprehensive understanding of structures that transcends the model of systems.

V – Emergence and Explanation

Causes

Earlier we discussed formal causes. Consider, for example, Galileo's law of falling bodies where the speed at time t is equal to 32 times t squared. This does not provide us with the cause for the body falling. Rather, it is a mathematical relation discovered in concrete, mathematically ordered data. The formula is an account of what a free fall is. It corresponds to Aristotle's notion of formal cause. A number of "laws" can be understood in this way. For example, physicist's still do not know completely what kind of force gravity is. They cannot explain why two bodies are attracted to each other. But we do have precise mathematical formulas for measuring gravity, which tell us something about the relationships between the bodies.

Part of the issue is that these "laws" are general and abstract from particular situations. This has two implications. The first is that the law metaphor is only approximate. The relation is law-like because it is general and abstract. A thing within a situation is subject to multiple relations and conditions. The instantiation of the relation, or "law", varies nonsystematically from the ideal relation.

Secondly, if one considers the relations only as abstract the mechanistic notion of universal relations necessarily linking relata becomes possible. This notion of system has developed into one of the major cognitive science models of mind as cybernetic. The computational model is more general and flexible, but, at root, relies on the same types of rule driven relations. The cognitive fallacy is taking the ideal universality and necessity as pertaining to real rather than ideal relations. As ideal they pertain to mathematics and symbolic logic, both of which deal with formal relata.

If we return to the particular situations, we may think that we can account for an event by tracing back a causal chain of events. Any attempt to do so, just as any attempt to predict occurrences in a situation encounters an expanding tree of histories of elements. In the ideal historical reconstruction these histories converge on the situation. In the predictive situation, they diverge. The foundations of statistics rest on the notions that different histories can lead to a limited set of results, as in flipping a coin, and that there is no set of laws linking these histories. This leads to the inverse insight that, because there are no links among the histories, they do not make a difference. So in a set of situations in which there are only two outcomes (heads or tails) and there is no reason one should occur more often than another, the ideal frequency of events would be .5 for each. However, precisely because the sets of events leading to the outcomes are nonsystematic, one would not expect that the ideal frequency would be attained all the time. For different types of distributions based on different types of events, ideal frequencies can be assigned to probability distributions themselves. Again, we would expect a nonsystematic divergence in any set of actual distributions.

This notion of distinct histories is sufficient to grasp the notion of ideal frequencies, but it is not sufficient to grasp the form of world process and complex organisms. To understand situations, we cannot think only of some sets of historical threads converging to yield a particular aggregate of things and events at a particular time. Because there are multiple conditions for all occurrences, each event in the ideal historical thread can have multiple conditions converging just as the event for which we are attempting an historical explanation does. We have aggregates yielding aggregates. This fundamental fact of the unpredictability of events due to non-linear process underlies chaos theory. However, we can discern order in situations and in some cases we can provide historical explanations. It is to these notions that we now turn.

The structure of two hydrogen atoms and one oxygen atom alone does not explain why they combine to form a water molecule. That explanation is historical. Rather, the explanation of the structure tells us why they *can* combine. To understand why they *did*, we need to understand why they were in the states where they *could*. In cases where the efficient cause includes the nonsystematic convergence of conditions, the emphasis shifts to the formal cause as efficient and external relations decrease in significance. This is quite a different universe from the mechanistic or systematic or fully intelligible. It is not simply that things and events are contingent and that knowledge of them is factual. It is that efficient causes as "external" are not sufficient to explain many things and events.

This accounts for the fact that emergence cannot be explained in terms of antecedent events. Organizations emerge because they can. The event itself is invoked to explain it. There are conditions for emergence, but they are not sufficient to explain it. When these conditions result from nonsystematic convergence there is no set of relations, which account for their existence at this particular place and time. When an organization emerges, the organization itself must be invoked to explain its existence. This is because complex organizations are of multiple elements and, concomitantly, multiple relationships. While each relationship can be explained in terms of the relations of the elements to one another, the set of relationships cannot be. Consider equipotentiality, for example, where the same elements can form different structures. We found a similar situation in organizations that we found in histories. In histories we can conceive of a causal chain, but there is no overarching intelligibility to the whole. In organizations there is an overarching intelligibility, but it is not explained by the individual relations. Rather it is the interrelation of these relations. Just as we can have different histories with different elements, so we can have similar structures with different elements. Thus, both histories in the sense of process and emergent organizations occur because they can.

Similarly, in a weaker sense of organization or system or structure we have cycles of aggregates or populations, such as weather systems, waves, ecologies where there are global impacts and qualities that cannot be explained simply in terms of the populations' elements, but which relate to its size, coherence, and so on. Thus, aggregates of different materials, such as sand, can only attain piles of certain sizes. These constraints can be explained in terms of the physical and chemical properties of the sand, though the constraints leave open the characteristics of the particular aggregates.

Holism and Evolutionary Differentiation

The evolution of development was the evolution of constraints that permitted independent internal processes to yield results that led to the emergence of more complex structures or integrations. The internal environment became richer. There always has been an issue with adaptation to variation within the internal environment. For a species to survive, it became advantageous for a gene pool to evolve where development could accommodate greater variation resulting in variation in structure within the species, so that the species could yield behavior that would survive the vicissitudes of significant environmental change . This evolutionary gradient yields a development within the constraints set by the gene pool and its resulting range of structures at each stage of development analogous to the accommodation of the organism to the external environment. Is this surprising? Conceptually it is not, if we consider the organism not in isolation, but as a thing whose behavior is what it is because elements that are not it are integrated within its functioning. That is, for the most part, it does not behave or perform without incorporating what is not it within the behavioral schemes of recurrence. So the basic performance of the organism within its habitat is exploited in the emergence of development.

The evolutionary "strategy" was for systems, which support key activities to become differentiated from one another. This differentiation was possible due to the emergence of greater complexity. For example, the reproductive, metabolic and motor functions became differentiated within the cell. The development of a nucleus in the cell provided a more complex and more specialized structure. As the cell membrane provided boundary conditions within which the cell could perform its functions, the nucleic membrane provides the same function within the cell. Not only does this secure advantages in the life cycle, it also provides a greater flexibility for evolutionary innovation since evolutionary changes can occur independently of one another within the systems within ranges that can be assimilated by or accommodated to by the other systems. A similar process occurred with groups of cells. The unity of cells as one organism evolves into partially independent systems of cells that perform key functions. These systems may be or have operational or organizational centers that have some autonomy with respect to other systems. The organization is modular where many of the processes within the modules are separated by boundaries from processes in other modules but where rich interactions can occur via biochemical processes. As these systems became more autonomous from one another, they became subject to "external" regulation, as systems evolved to coordinate the activities of other systems. The same process has been reiterated with respect to those systems. A case in point is the evolution of the motor system. As muscular groups became increasingly differentiated from one another, they also became more coordinated through the evolution of the nervous system. The nervous system itself was subject to the same general evolutionary principle as neural centers evolved to support the various senses and movement. It appears that differentiation and new coordinations are linked.

A key point is that the unity of the organism is maintained. This is illustrated by the fact that in animals, no self organizing processes survive death and those that do (i.e. the growth of finger nails) soon stop. This means there is no fully independent process in the organism. Everything is interdependent. If non-related processes emerge there are complex processes that occur to eliminate them, such as the triggering of cell death and the processes of the immune system. Diseases such as cancer and viral infection survive and reproduce by mimicking the organism's protein or by affecting the processes that would destroy alien protein. However, neither survives as actual process without the living organism.

The holistic interdependence of the organism suggests that the notion of hierarchical structure is misleading. Rather than the image of the organism or systems being structured like a pyramid with the central operator being at the top, a more apt image is an inverted pyramid which represents the development of the organism with the top of the pyramid representing the latest configuration. The latest configuration is the organism as a whole with a potentially integrable set of operations. Any distinction of levels is abstract, partitive, and potentially misleading.

Structure and Stochastic Relations

The correlate to classical laws or relations in understanding organizations is the system. The notion of system is subject to similar limitations in understanding the concrete situation. The situation is nonsystematic. Since living systems are open, meaning that elements of the environment are components within their systematic cycles, they need to be adaptable in the situation in two major ways. First, if there are multiple cycles where the environmental elements are available nonsystematically, then the cycles need to occur as the elements are present. If multiple elements for multiple cycles are available, then some selection criteria, or means of selection, are needed for cycles to emerge without conflict. This requires internal regulation of cycles. Second, if there are environmental elements which can disrupt the cycles and put the organism at risk, then there need to be processes or structures aimed at excluding or destroying these elements or repairing any damage they have done. Within a complex system the same types of threats and opportunities can be present as a result of the systems own activity.

This variability permits evolutionary change beyond mutations of DNA. Since development is the emergence of new cycles, schemes of recurrence or performances, the same situation occurs at each point. This means that each point in development is a possible occasion for variation depending on the situation, which is multiply and complexly conditioned. [4] It is multiply conditioned since there is more than one condition. It is complexly conditioned since the conditions result from the processes of other elements and since their occurrence may be coordinated or "timed".

Considering that systems can be in states other than their current one, it is not paradoxical that systems rely on a lack of system for their functioning. Their potentiality for reintegration could rest on having some unintegrated elements at any one time. However, it is also possible to conceive of a system with multiple states with no unintegrated elements at any time. So let us discuss some of the virtues of the nonsystematic aspects of complex structures and some areas where they can be exploited in biological structures.

The simplest case is a set of similar elements where the existence of the set permits operations, or has qualities, which the individual elements do not have. Consider a set of muscle cells constituting a muscle fiber. The strength of the muscle fiber is related to the muscle cells, but the relation is not reductive. Up to a certain point, the loss of individual cells will not affect the strength of the fiber. Likewise, a threshold is reached where more cells may interfere with effective action of the fiber. Thus, there is a range, which constitutes the effective number of muscle cells within a fiber. Dealing with the individual cell itself as individual, it either is there or it is not. Thus, the notion of range does not apply to it as an individual, though it may apply to processes within it. The fiber itself has a range of extension or flexion, which is effective. Beyond that range it suffers atrophy or tears.

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[4] Emergence of Complex Systems, pg. 54-5

The functional independence of the group from the individual permits a turnover, or renewal, of individuals within the group without loss of function. It also permits greater flexibility in controlling the operation of the group, since the activation of the individuals can occur within ranges and since all individuals within the group do not need to be activated for all operations of the group.

Individuals within a group can be related to individuals within another group permitting situations in one group to cause a corresponding situation in a different kind of group. In other words, a population can create or contribute to a situation, which is related to other situations in other populations. A population of cells creating hormones in a gland for use by other populations of cells in other parts of the body is an example. Again, it is not the individual, per se, that is important, but the number of individuals and their collective state. That collective state does not need to be a higher level of organization but can be understood statistically.

Stochastic relations can be qualities that the group can have that the individual does not have. The relations are not isomorphic to relations obtaining in the individual since, clearly, the individual is not composed of a population of itself. It is simply one element, or variable, within the group. Thus, stochastic relations cannot be understood reductively, or in terms of the individuals and their immediate relations. This type of structure corresponds to the mass action of aggregates noted above.

Stochastic relations provide some means of understanding the linking of situations to one another, even if they are of different elements. If we consider stochastic relations obtaining among the parts of an individual, then we have some understanding of the qualities or properties of the individual in terms of them. This provides some explanation of how unpredictable qualities can arise within things, providing a type of emergence complementary to that of more systematic organization. It also provides some explanation of dysfunction, since the level of production of biochemicals, for example, may not be sufficient to support the activities of the threshold number of another population. Consider the production and the levels of neural transmitters in the brain and their relation to mood disorders.

The stochastic relations among situations provides some understanding of performance. This is understood by understanding how the visual system enables sight. In the retina are an aggregate of rods and cones, which are specialized to some extent to respond to different facets of the visual field, such as direction of movement and intensity and wave length of light. The aggregate of neurons in the optic nerves radiates onto other visual processing centers. These other centers are more complex than the initial processing center. They deal with feature recognition and other higher integrations of visual input. They in turn are related to other neural centers for other types of operations. The state of the population of neurons emanating from the eye conditions, but does not determine, the state of the neurons in the other centers. In fact, their state is conditioned by the inputs mediated via the eye. Thus, though the inputs are single, as a population they may constitute a pattern, which is matched by the patterned response of the rods and cones.

The lack of an overall organization permits the system to be open enough to handle a range of visual experience. Also, it is the lack of an overall organization between centers that permits a range of combinations of operations. The existence of stochastic relations, then, makes a system more open, more flexible, and more unpredictable.

In the visual field, for example, the positions of structures in relation to the eye are not static. We see them from different angles, in different light and so on. This means that different rods and cones are involved in seeing it at different times. Different sets of neurons are involved as the image is constituted, yet the same image is presented for consciousness. The neural function can be understood as a dynamic pattern of operations, which can be actualized across a network of neurons. Though the network may map fairly tightly to the sensory sources, since the sources themselves are equipotential with respect to providing elements for structures, or gestalts, the network must be able to handle this variability. The neural network makes patterns possible, but it's action is not sufficient to explain why the particular patterns are as they are.

We have concentrated on events or relations between events that need to be understood statistically. The timing of events and the relations of these to one another can also be systematic or nonsystematic. As nonsystematic the organism's organization in terms of them may require the development or learning of the proper timing and sequencing.

In the next chapter we will discuss the matrical structure of the brain and understand how neural structure enables performance. Corresponding to the neural network is the matrix of operations, which it supports. Consider first that neural networks, or centers, or areas perform different operations. Second, they have pathways that intersect permitting the coordination of these operations. Third, the operations can be combined in various ways yielding a myriad of possible combinations. Since the same operation can be combined with numerous other operations, there is a matrix of possibilitiesconstituting the flexibility of the system. This provides us with an initial understanding of the possibility of actualization and of the body as enabler of performance.

The advantage of a matrical structure is that different organizations can emerge transiently. It has an openness and adaptability that a stable hierarchical structure does not. With a matrical structure a variety of hierarchical organizations can be supported without the addition of more elements.

Life as Intrinsically Nonsystematic

Thus far we have understood how structures can be non-systematic. At this point we can understand how life is intrinsically, though de facto, nonsystematic. This requires expanding the notion of schemes of recurrence from sequences of events to states.

Earlier we noted that attempts to understand the emergence of life have floundered on two issues. The first is the attempt to understand its complexity systematically and the second is to understand reproduction as requiring a DNA like template. Since life is reproductive, somehow an extremely high level of complexity needed to emerge. The notion of schemes of recurrence, or cyclic processes, provides some insight into emergence. If a scheme is possible where A causes B which causes C which causes D which causes A, then all that needs to happen is for any of these events to occur to initiate the scheme. Now, the scheme does not cause itself in the sense that it generates its own conditions, but it is part of the cause in that it becomes itself. Thus, emergence has two causes, the conditions for the initiation of the self-sustaining process and the process itself in its becoming. In this sense, emergence can be fully explanatory though there is a logical gap between the assembly of the conditions, the conditions as unorganized, and the resultant scheme as organized.

The emergence of life is not simply the emergence of schemes, but is the emergence of a whole. The most basic question is what kind of structure does the whole need to have to be a self-sustaining whole. As self sustaining, life does, in a sense, reproduce itself within itself. As reproductive it produces another. A clue is found in the work of Stuart Kauffman.

> We reach a new and fundamental conclusion: for any fixed probability of catalysis P, *autocatalytic sets must become possible at some fixed complexity* level of numbers of kinds of polymers. The achievement of the catalytic closure required for self-reproduction is an *emergent collective property in any sufficiently complex set of catalytic polymers.*[5]

These would be structures of interrelated bio-chemical processes which recurrently replicate states of polymers sufficient to maintain existence as a whole. In this case we need to shift from a consideration of schemes of recurrence where the schemes are linked sets of events to the recurrences of states. The notion of a whole as having recurrent states is compatible with a unity of independent processes yielding results in the context of a schedule of probabilities. It is

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[5] Kauffman, The Origins of Order, p.310

this notion which underlies Kauffman's hypothesis of the origin of life consisting not in the emergence of a self-replicating entity embodying some type of DNA or RNA like template, but of a bounded set of biochemical processes open to the environment that maintain a threshold of cycles of reactions that maintain existence within a range of states. There is enough order to maintain existence and enough disorder to permit adaptation to the environment and subsequent internal specialization into metabolism, reproduction and development.

From these principles we can move very quickly to a set of criticisms and conclusions. First the notion of a matrix of relationships provides an instance of a combinatorial model that would be understood statistically. The matrix becomes more robust explanatorily if we understand it as a set of events, operations, or elements in general which are not fully related. Kauffman has called for a new "statistical mechanics" to understand the complexity of biological processes.

Second, we can understand stages of development as the emergence of different matrices of relations where the emergence of a "higher" or more complex integration is akin to an instance of adaptation to a complex situation. The integration is not fixed, but flexible. The notion of moving to a different stage is not that of moving to a more systematic functioning, but to moving to different principles of operation as structuring performance, where performance is understood in these cases simply as the organization of operations. This contrasts with the fuller notion of performance of an organism in an environment where the performance incorporates elements which are not the organism. In development parts of the organism can be involved versus the whole organism. In performance, the whole organism is committed via its actions.

Third, the need for flexibility selects against fully systematic organisms. Rather the role of systems is subsidiary. They function best in controlled environments with a fixed set of elements that the system processes so it can deal with every situation. Thus, we find systems within the body, but development and performance are the non-systematic integration of systematic processes. Rather than organisms evolving to be more systematic, they evolve to become more flexible. Because life relies on what is not itself for its survival and reproduction, living systems are open. Because the external situation can change, affecting the availability of what organisms rely on, they must be adaptable. They must be able to replace one element with another within current processes – like assimilation – or change the process – accommodation. If they do not, they die, and the organisms which can adapt survive. This is basic natural selection. But it would seem then that evolution itself selects for the more adaptable organisms, or those which have more flexibility in situations. Since the non-systematic is more flexible than the systematic, the non-systematic is intrinsic to life.

Fourth, the limitations of Boolean or cybernetic models including computational models are apparent. Boolean models rely on binary alternatives. While it has been shown that they give rise to complex structures, organic structures rely on physical-chemical processes in their inception and an array of evolved operations in their performance. The actual organism is exponentially more complex. Similar reasoning applies to the computational model which essentially comprises parallel processing Boolean networks. Parallel processing occurs in organisms but it is comprised of a matrix of different kinds of processes versus an array of similar processes. The model for understanding is not matrix algebra, but akin to the call for a more robust statistical mechanics.

The Other as Intrinsic to Life

If we focus only on the internal structure of the organism we can make a mistake akin to focusing on the sciences as applying only to their set of corresponding things. The organism does have internal states that are independent of what occurs in the environment or Umwelt, but it does not follow that the organism is just as independent. In fact, elements of the environment are incorporated into both the merely operational and the performative schemes of recurrence of the organism. Most basically, we require constant chemical exchanges via breathing and eating to survive. As "other than us" air and food, for example, are incorporated into our functioning and our functioning is organized to some extent in terms of them. The orientation to the other is intrinsic to life. Life creates some of the conditions for its existence but needs to incorporate others. This intrinsic orientation or relation to the other creates another evolutionary bias, asymmetry or pathway, which is exploited in the emergence of ecologies. The other is transformed due to the activities of life or because the other is another living creature with its own evolutionary possibilities. The former occurred in the transformation of the atmosphere to having 18% oxygen. A case of the latter is the effect of the evolutionary adaptation of having large numbers of offspring to insure that some survive to a reproductive age. The byproduct is the emergence of a large food source for other animals.

Rather than being a weakness, the intrinsic orientation to the other becomes a rich source for evolutionary change and for developmental possibilities. The emergence of social animals is a premier example. Another is cognition. We will deal with both these areas later in more detail. At this point we can illustrate our point by providing an example that embodies both elements in understanding the role of social interactions in language acquisition.

We have focused on life as an open whole and its emergence and development. In development the conditions are constrained. It is the lack of constraint over environmental conditions that contributed to evolution. However, just as life constrains the conditions for development, there are similar strategies employed in transforming the external situation. There also is the transformation of the environment to enhance organism's habitats. Organically we see this in the creation of top soil by plants. In animals we see it in the emergence of social behavior that supports or yields learning, the existence of complementary behaviors within the group in hunting, raising the young and so on. The interaction within the group is part of the situation within which animals, or persons, find themselves and elements of it are necessary for individual development. Society in the broadest sense evolved to the point of enabling individual development. It provides external constraints to and external conditions for conscious development or performance. The quintessential example for humans is learning language.

Language acquisition illustrates the general strategy of embodying learning via critical periods. The general structure is that a motivational window opens that is biologically supported to develop a set of skills, be it recognizing visual patterns, walking or speaking. In the case of speech there are a series of linked emergences of verbal skills. The first is the universal, or transcultural, stage of babbling. Here we see the evolved strategy of supporting a broader array of operations than will be selected to support a wide variety of situations in which the infant may find themselves. Thus, humans can learn any language in any culture in which they grow up. The babbling phase terminates with the selection of the range of speech sounds required to hear and speak the community's language. Ability to hear some of the sounds supported earlier goes away with the counter intuitive result that native speakers sound different to native hearers than they do to non-native hearers because they hear differently. Moreover, this transformation provides the imaginal conditions for understanding language since experiencing is attuned to the sounds that constitute the spoken word. Not only do we see the principles of over-differentiation and flexibility at play, but also the constitution of the environment to support development. This is evident in the need for "complementary babbling partners". These are not peers, but "teachers". Adults and other mature language users babble and engage in other word play with the infant, and these interchanges are instrumental in the development of the particular language for the child. Thus, the child's development and consequent biological transformations are conditioned by and dependent on the society with which they interact. These facts themselves are not surprising. But what I hope has proved helpful here is the sketching of a model of structure which helps explain them using the same principles that explain development, its emergence, and the evolution of adaptability.

We will extend this model to the organism as a whole in the next chapter via the development of the model of the operational situation. At this point we will return to more standard issues in the philosophy of biology to show how explanations using statistics and the notion of the non-systematic can address three critical questions:

1) How could life evolve if it had a low probability of emergence?
2) How can we explain the acceleration of evolution?
3) How can we explain the emergence and survival of greater organization given the second law of thermodynamics?

In addition to illustrating the efficacy of understanding the non-systematic for explanations, we will understand what a situation is in the most general sense, which is a pre-condition for understanding the model of the operational situation.

The Probability of Life

If we consider the state of our solar system five billion years ago, life's emergence was an extremely improbable event. Yet it occurred. Moreover, even though it was very improbable, it was virtually impossible that it not happen. The same is true of the emergence of more complexity in evolution. A brief discussion of the nature of probability will illustrate these points.

In the simplest cases, probabilities are arrived at by considering the number of possible combinations of independent events. For example, in the flip of a coin, there are two possibilities. Assuming independence of the events and the processes leading to them, the probability of a particular occurrence of heads is 1/2 or 50%.

To arrive at the probability of independent events occurring sequentially, you multiply their individual probabilities. The probability of getting heads two times in a row is 1/2 X 1/2 or 1/4. This can be understood in terms of a matrix of possible occurrences. There are four possibilities.

First Toss	Second Toss	Probability
Heads	Heads	25%
Heads	Tails	25%
Tails	Heads	25%
Tails	Tails	25%

However, if we assume that heads occurred on the first toss, the probability of getting heads two tosses in a row increases to 1/2.

First Toss	Second Toss	Probability
Heads	Heads	50%
Heads	Tails	50%

In general, if an event becomes possible when certain conditions are met, then the probability of that event occurring prior to the conditions being met is the probability of the conditions occurring multiplied by the probability of the event occurring after the conditions are met. If the conditions are met, then the probability of the event occurring becomes greater. In this sense one could claim that probabilities emerge.

In general, because the occurrence of an event is conditioned by other events, given the occurrence of those events, a new probability of the event emerges. The probabilities change as the situation changes. Whereas in some situations some events are impossible, in others they become probable. Thus, probabilities emerge as processes converge on situations.

What may seem highly improbable, such as the emergence of life, becomes highly probable given large numbers of occurrences and long periods of time. For example, the probability of me winning the Arizona Lottery is one in 5,245,786. However, the probability of some person winning the lottery is:

(number of unique six number combinations chosen)

5,245,786.

Thus, the odds of somebody winning is much higher than the odds of my winning.

The odds of somebody not winning two weeks in a row are less than the odds of someone not winning the first week. And the more instances we consider, the less the odds become.

For example, let us assume that 50% of the possible combinations were chosen. This makes the odds of someone winning this week 50%. The odds of someone not winning are also

50%. The odds of someone not winning two weeks in a row are .5 X .5 or .25. For three weeks it is .5 X.25 or .0125. Four weeks is .00625, five weeks is .003125, six weeks is .0015625, seven weeks is .0075125, and so on. Conversely, the odds of someone winning within seven weeks is 1.0 - .0075125 or .9921875.

By extending this reasoning, we can see that given a sufficient number of trials, the occurrence of any event becomes almost certain. For example, if an event has a 1 in 1000 probability of occurring in a single trial, it would have a probability of 19,999/20,000 or .99995 of occurring within 10,000 trials.

Thus, given large enough numbers and long enough periods of time, all possibilities to which a probability could be assigned at some point in the universe of processes are almost certain to occur.

The Acceleration of Evolution

Instead of seeing evolution slow down as more complex systems emerged, it has accelerated. It took about two billion years for (cells with nuclei) to emerge. Once they did, it took a relatively short time of two billion more years for humans to emerge. We have seen that greater complexity corresponds to a greater variability of function and action. Evolutionary differentiation, with its modularization of functions and systems, permits the combination of elements in unprecedented ways. This provides for adaptability within development and the adult life cycle.

In turn, this permits action to be a cause of evolutionary advance. In fact, this can be explained partially in terms of survival of the fittest. Consider, for example, a situation where prey becomes scarcer and harder to capture for an animal. The ones who can behave in such a way as to capture enough of the remaining prey to survive will reproduce. Those who cannot, have a lower probability of reproducing. Thus, the composition of the gene pool will tend to shift towards supporting the successful behaviors. In turn, the conditions for the emergence of more effective organizations of behavior shift also. If we consider that the situation is iterative, that is, that there will be recurrent situations where it is difficult to catch prey given the current behavioral system, then we should expect the behavioral system to advance evolutionarily. How far it will advance will be dependent on the potentialities in the gene pool. However, there should be a drift towards more effective action until the potentialities play themselves out. Paradoxically, then, the more adaptable a system is, the greater its potentialities for evolving. The paradox is that one would expect more adaptable systems to be more stable since they can survive in more varied situations. However, if these situations have a directionality, or bias, then the population will evolve in a compatible way or become extinct.

The evolution of species, then, is conditioned by the course of evolution as a whole. For example, if more adaptable populations of species are evolving, then individuals find themselves in more variable situations since they are confronted with greater possibilities of behavior from other animals in their environment. This in turn applies greater evolutionary pressure for more varied behavior for populations to survive.

This notion can be generalized to all contexts of complexity. In the course of development and the life cycle the inner environment is constantly transforming. The situation for internal systems and subsystems is similar to that of the organism in the environment. Though the inner environment is subject to more controls, as we have noted, nonsystematic situations can arise.

Also, the variability in the gene pool requires that the subsystems in their development be compatible with ranges of possibilities in the types and combinations of other systems. If we consider that a human gamete has twenty-four chromosomes and that each of them is either from the mother or the father, we have 2*24 possibilities of different chromosomal makeup for the gametes of one parent. With two parents we have 2**24 * 2**24 possibilities. These possibilities regard only the combination of chromosomes. The possibilities for the combination of genes could be greater. These numbers alone indicate that living systems are not mechanistic, but extremely adaptable. Otherwise they could not incorporate the variability that life presents to itself in its own development. This indicates that life exploits the nonsystematic in development as well as in evolution.

At each stage of organization or development, then, the same possibilities for evolutionary advancement exist as at the level of action. No wonder, then, that evolution has proceeded more rapidly as complexity has increased. There are more possibilities for nonsystematic situations.

However, the possibility that action can contribute to evolution, and that most internal changes are evolutionarily efficacious insofar as they improve biological functions which ultimately support actions, indicates that evolution works through the highest level of living organizations. This view would be compatible with the fact that humans are beginning to direct their own evolution through biological engineering. It implies that the evolution of mind, insofar as it provided greater adaptability, became a condition for its further evolution. For example, as it gains greater possession of itself in the actualization of scientific method, it gains greater influence on evolution. We are at the point where a new principle of self-knowledgeable evolution can emerge.

Entropy

Another paradox associated with the emergence of life is that it seems to violate the second law of thermodynamics which is the basis of the theory of entropy. Entropy currently has two interpretations, one in physics, and the other in information theory. Life seems to challenge both.

The physical theory of entropy is based on the second law of thermodynamics which is generally interpreted to mean that the disorder in a system or situation increases with time. A common example is to consider a box with two compartments. In one is a gas which is hotter than the gas in the other compartment. The side separating the two compartments is removed. As the gases mix, the resulting mixture assumes a constant temperature. This is because the molecules become mixed. The mixing is a decrease in order. Assuming the system is closed, there is the same amount of energy as there was before. It is highly improbable that a reversal of the situation would occur, where the temperature in the one compartment rose to the original temperature. The situation should tend towards its most probable state. This provides a temporal direction to the situation. It is not likely to be reversed. It also shows that in this situation, there is a tendency towards disorder. Entropy is a measure of the disorder in the system.

Problems arise when entropy becomes a metaphysical principle. It has two parts. First, every situation tends towards its most probable state. Second, disorder is more probable than order. Thus, the universe and its component systems should be tending toward disorder. Both these statements are wrong. The first rests on a misunderstanding of probability and statistics; the second on a metaphysical misunderstanding.

Though one can assign probabilities to single events, probabilities are understood by understanding multiple events. A particular situation does not tend towards its most probable state. Rather a situation tends towards a range of possible states, where each possibility can, theoretically, be assigned a probability. A set of situations would tend toward the ideal distribution, or set of frequencies, given enough trials and time. But this means the less probable would occur, just as the more probable would, though the less probable, naturally, would occur fewer times. The gas in the example above would tend to stay in a state of high entropy since, once it is mixed, there is a significantly higher number of "disordered" rather than "ordered" states. But this is not to claim that its temperature would be the same throughout the system all the time. Rather we would expect some variation in temperature, small though it would be, due to local differences in molecular activity.

Considering the second assumption, it is true that situations tend towards disorder. But it is also true that they can tend towards order. It depends on the situation. In the situations preceding life with the existence of large numbers of independent chemicals and events, the probabilities for the emergence of life were very small. However, now that life has emerged, according to this assumption, it should be tending towards disorder rather than order, since this is the more probable state. The problem with this analysis is that it neglects the full situation, particularly the nature of what has emerged.   However, if we consider that probabilities change as the conditions for other possibilities emerge, then life can become more, rather then less probable. This was the case as the organic chemical "soup" emerged in the early oceans. Given the existence of life, its probability of continuing, other conditions being equal, is virtually certain. Again, this rests on the kind of systems that have evolved, self-sustaining, reproductive systems. Their probabilities of survival are higher than their original probabilities of emergence.

Is it true that the universe is tending towards disorder? If it was, we could still explain life using Pierce's solution. Entropy can be increasing in the universe as a whole, though it is not increasing in living things. Localized areas of decreasing entropy are possible.

In fact there are localized tendencies towards disorder. In general, this is because every relata which is in a relation to any other relata is capable of being in similar relations with similar relata or in different kinds of relations with different kinds of relata. Within a complex system, the components can be organized differently at different times. It is also possible for them to lose a degree of organization. For relations to be fixed, or for systems to be stable, the influence of other elements must be reduced by having a closed system or by having a system which can handle the effects of inner change and outer influences. Living systems have a variety of strategies for doing both. In fact, we have seen that the ability to incorporate and exploit the nonsystematic is synonymous with evolutionary advance.

However, it would seem that the universe as a whole tends towards order. There is no absolute disorder. That would be chaos, where nothing would be related to anything else. In that case we could not speak of there being anything at all. For there to be disorder, or the nonsystematic, there needs to be something which is not in order. Disorder is simply the absence of relations. But if there were a complete absence of relations there would be nothing. So the universe, fundamentally, tends towards order. The questions are, what kind, when, and what are the frequencies?

In fact, the universe is a set of situations. Situations are aggregates of spatial-temporal unities and relations. Insofar as there are relations and unities they are systematic. Insofar as there are unrelated aggregates they are nonsystematic. If greater complexity emerges from lesser complexity, there is a tendency towards order. If a system has schemes of recurrence designed to maintain its current state or to condition the emergence of a more complex state, there is a tendency towards order. If a system breaks down, or a physical system dissipates, there is a tendency towards disorder. And so on.

Explanation

We are now in a position to more precisely discuss explanations. We have found that situations have both systematic and nonsystematic aspects. The systematic is explained via relations or groups of relations. The nonsystematic is understood statistically in terms of frequencies. Statistical method can be used to establish relations if a statistically significant correlation is found. These relations do not obtain in all instances but are associated with ideal probabilities and the actual frequencies which diverge non-systematically from them. Also, the occurrences of the systematic relations are associated with frequencies, as are the particular values that can obtain for a general relationship across a population.

The non-systematic also is related to what we have termed stochastic relations among populations.

Also associated with the nonsystematic is an historical account of the becoming of the situation or of a particular thing or organism. As we saw in the discussion of particles in a gas, the individual histories do not each constitute a law or fixed relation or intelligible set of fixed relations where the intelligibility is other than a sequence of events.

As part of the historical account, there may be instances of emergence of the more complex from the less complex. These instances can be explained in terms of the conditions for the emergence and in terms of the relations which emerge. The emergent relations organize pre-existent components. Emergence, then, can be explanatory. We distinguished two general cases, the emergence of new organizations, such as the emergence of life, and the more orderly emergence in development.

The fact that the more complex can emerge from the less complex in development grounds teleological explanation. However, rather than claiming that development has a purpose, or end, we make the more modest claim that in understanding development, present structure can only be fully understood in terms of possible future function.

In explanations in physics and chemistry proper, the present state can be understood in terms of its consequences to the extent that a relation between the two obtains, but the consequences do not explain the present state. If anything, the present state explains the consequences. However, in biology both the present and the future state must be taken into account to explain the present state due to the nature of the organisms being studied. This is less than the claim that a teleological explanation implies. Life, as self-organizing, causes its future functions, and, to a certain degree, its own future. In the discussions of evolutionary differentiation, emergence and development we explained how this could appear as goal oriented though in fact it is not.

This suggests a limit to explanations in terms of conditioned and conditions. It is possible to conceive of a series of conditions diverging into multiple branches as one moves from considering any single thing or event to its historical antecedents. Conversely, we can conceive of a series of historical sequences of events converging on the event or thing in this moment. Conceivably we could go all the way back to the big bang. While the big bang is, in a sense, a condition for life as it was the event that purportedly started the present universe, it does not mean that it explains life. Portions of the universe had to attain sufficiently complex states for the emergence of life to become proximately possible, that is, "at the limit", for the emergence of life to begin. In this sense, life is explained via its proximate conditions and the emergent living organization as is any specific instance of any emergence of a more complex organization. Why is this distinction non-arbitrary? It is because an account of what is prior to the emergence of greater complexity is only an explanation of it if you bring the emergent within the context of the discussion. If you do not, what is being explained is the pre-emergent state or process or whatever historical element is the topic. Thus, the big bang does not explain life as such because the event did not yield the proximate conditions for life. It can be invoked to explain the existence of life as a remote historical condition but it has no special role that distinguishes it from being a historical cause of anything else that has occurred since then.

This supports the general claim that we can explain some things without explaining everything. Given the existence of the conditions, we do not have to explain the emergent by explaining the coming to be of the conditions. To do so, is to explain the conditions, not the emergent. The emergent is what it is via, or as, the organizing of the conditions. Put another way, one can explain the conditions fully and not mention the emergent at all.

We find an analogous situation with respect to knowing and judgment as understood by Lonergan. The structure of judgment makes it possible to know some things without knowing everything. The conditions for a judgment are limited and are different than the conditions for the existence of what is affirmed. Thus, I can know that this particular tree exists without fully knowing what a tree is and without having to know or affirm the existence of every thing and event that led to the existence of this particular tree.

These considerations indicate the remote possibility of having independent sciences legitimately pursue currently irreconcilable explanations. Ideally, in the long run the sciences will prove complementary and be reconciled. But in fact they have established many of their results independently of each other. In turn, reconciliation is not automatic nor de facto, but requires additional understanding.

This is important to us because we are considering a model that will reconcile the sciences with respect to the understanding of organisms, consciousness, minds and persons. It is important to be able to properly distinguish and relate their contributions so that we end up with a model that is not truncated because it collapses one science into another or does not acknowledge the contribution that a particular science has to make, on the one hand, or a model that is ideal and non-explanatory on the other. It is to the second concern that we now turn in a discussion of metaphor, analogy and explanation and how they relate to developing a model that can be concretely explanatory.

Metaphors, Analogies, Precision and Abstraction

We are in the process of developing and presenting explanatory models. As models they are abstract. As explanatory it would seem logical that they also are abstract. However, this does not mean that explanations cannot be concrete and that models cannot be used to develop concrete explanations. It follows that we need to understand the difference between the concrete and the abstract and how we mediate between them. Doing so permits us to address a couple of issues, the role of metaphor and analogy in knowing and science and the notions of precision as ideal and as concrete.

A first approximation to metaphor is given via an understanding of analogy. Analogical understanding posits some isomorphism between two separate intelligibilities. For example, A is to B as C is to D. Newton used inverse squares to understand the propagation of light. He used them the same way, or analogically, to understand the strength of gravity. Piaget used the notion of groups of operations analogously to the mathematical Structuralists. Metaphor, on the other hand, uses language and images suitable for understanding one set of intelligibilities to understand another set for which there is no direct isomorphic relationship. Whereas the relational structures of what is related analogically can be the same (i.e. in functionalism), the relational structures joined by metaphor are not the same, nor may they be known. Thus, there are two dangers with using metaphor. Since metaphor has an imaginable or associative component, the relations can be misunderstood because the image or association is not appropriate. Secondly, because it is easier to embody metaphorical meaning than explanatory due to the imaginative and emotional link, one can be led to thinking that understanding the relations metaphorically is at least equivalent to, if not better than, understanding them explanatorily. In metaphor's symbolic role it introduces the feeling that the metaphorically expressed makes sense or is correct which also can lead us away from explanation per se.

The structure of metaphor is a cluster of related terms which evoke one another in non-specific ways. At their core is a common intelligibility they express, but they do not express it in terms of the intelligibility itself, but in terms of other intelligibilities, the associations of which permit some expression and understanding of the intended intelligibility. Relational but not precise, analogous but not quite, and used artfully to communicate meaning, metaphors, as noted above, can lead to unintended meanings entering systematic thinking.

Examples abound in ordinary language or common sense expression. For example, spatial metaphors commonly are used to understand feelings where some feelings are superficial or shallow and others are deep. The spatial metaphor correlates non-rigorously to the quality and intensity or strength of feelings. "Strength" itself is metaphorical with feelings being either strong or weak.

Metaphors commonly are used to understand knowing. The metaphors of vision and light are the best known. Understanding and knowing are expressed by “seeing the light”, “illumination”, “viewpoint”, “world view” or “I see”. The iconic light bulb symbolizes insight. The visual metaphor overlaps with the spatial metaphor for knowing and the known. “Objects” are “in the world”. The mind is “inner” and the world is “outer”. “Objects” “stand over and against” us. In some cases experience is of appearances while the thing in itself is “behind” the appearances.

There are good reasons why these metaphors are apt. We are embodied knowers in performative situations. There is good reason to believe that knowing for its own sake evolved from the role of knowing in action where truth and value were not the goals per se but successful solutions to problems in living were. However, if knowing is understood in terms of these metaphors, grasping an adequate explanation is difficult. We need to transcend the imaginative correlate of the metaphor. Though it may be useful to initially identify insight as “seeing the point”, the spatial implications of the metaphor result in problems. For example, much energy has been expended on bridging the gap between the knower as inner and the object as outer. Once it has been bridged, both are somehow inner, though one is still outer. So the metaphor begins to break down rather quickly. The limitations of understanding and knowing sometimes are phased in terms of viewpoints. We each have our individual viewpoints. How do we get “outside” them to understand another’s? The explanatory viewpoint has been likened to a “God’s eye view”, which we cannot have since we are confined to our narrow viewpoint of which we cannot get outside. Rather than demonstrating the limitations of knowing, these metaphorical uses illustrate the unrestricted scope of knowing. How can we know our viewpoint is narrow or that God has a viewpoint? We need to transcend our particular embodied situation to make these distinctions. Again the literal interpretative bent of the metaphor lands us in paradoxes and contradictions that cannot be resolved in terms of the metaphor.

"Within" the mind as "inner" we find a "stream" of consciousness that is "on the surface". "Beneath" it, we find the field for "depth" psychology, the unconscious. In some cases we find a situation similar to understanding "outer" objects. Consciousness is of the phenomenal mind, or the appearance of mind, while the real mind or the real person, is "deeper", not experienced in itself and somehow accounting for or causing the appearances.

Other metaphors for understanding and knowing related to meeting problems of living are "grasping", "fitting" or "good fit". The metaphor of "fit" trades on the intelligent resolution of problems where how to make something fit requires insights that find pragmatic and, sometimes, kinesthetic verification in realizing a "good" fit. So "good fit" as a general metaphor refers to a set of insights that "hit the mark".

Because our initial understanding of understanding and knowing is in metaphorical terms and because our understanding develops within a performative context, to shift to a fully explanatory view requires a transformation of images for knowing to those which mediate explanatory understanding. In turn, these images are transcended in the intelligibility of explanatory understanding, though they may be required for understanding to recur. With the shift from metaphor as link to the embodied performative situation to intelligible distinctions and relations, there is a reorientation in our notions of relevance, reality, and objectivity from the palpable to the ineffable, from the imaginable to the intelligible, though the embodied, performative situation remains. The shift is from relying on the material embodiment of meaning, in a semiotic relationship for example, to the intelligent recognition within an intelligible performative situation. Again, this corresponds to the shift from the literal metaphorical interpretation to an explanatory understanding of the intelligibility the metaphor strains to express.

Understanding relations as natural laws was a once prevalent metaphor that was discredited as statistical understanding developed. Current metaphors include the notions of organic and neural "communication" and neural functioning as "computation". The metaphor of the machine was used to understand a number of things and processes mechanistically. In fact, there is a need for science to utilize images of current technology in developing science, but these should not be carried over uncritically into the scientific models. However, this is done unabashedly in some cognitive science where the computer is understood in terms of the mind. Once this is accomplished they turn around and understand the mind in terms of the computer without reflecting on why they came to understand the computer as being like the mind in the first place.

This is not to say that metaphor is not useful in science. It is useful in discovery to attain understanding and in teaching to communicate it. But scientists need to be on guard to keep from importing unacknowledged or unverified relationships into accepted scientific theory. Explicit communication of theory can have implicit or merely implied meanings if the relationships are not fixed or fully understood.

A second issue is implicitly or uncritically utilizing formal characteristics in theories or models. The major example here is mechanist determinism which rested on a formal notion of precision and projected the necessity immanent in some understanding onto existence or the concrete world.

There are at least three senses of precision. The first is the more common notion of precision in actions such as measurement or observation. The second is in the use of terms where they are not simply used in the same way, but with the same meaning. The third is formal. An instance is the idea of a circle as perfectly round. Another is the notion of essences as eternally the same in all instances. The third can be expressed via the second but it refers to the use and understanding of meaning itself. A concrete scientific explanation embodies all three. It is the third type of precision used without reference to the first or in conjunction with a reified understanding of the first that leads to the mistakes of mechanism and to misunderstanding a whole or a thing in terms of hierarchy theory. In the precise understanding of things and relationships the non-systematic can slip away. More precisely, it is abstracted from particular situations. Thus to understand a situation one has to mediate the abstract via insights into the particulars of the situation.

This notion of abstraction explicitly requires some understanding of understanding. A first approximation is that as abstracted, relations focus on particular aspects of things or relata to the exclusion of others. But it is not a simple matter of distinguishing and identifying them. Rather it is a matter of understanding the relations among them which are not given, but discovered via the data or images via a series of insights which transcend both images and data. Mechanist determinism found its attractiveness in focusing on sequential processes rather than states. In focusing on the single sequential process it also prescinded from fully considering the convergent series of processes that could be affecting each stage of the single process. Thus, the non-systematic was not considered because the relations were abstracted from situations – or the coincidental or aggregate in situations by inquirers seeking to understand relationships.

Now the closer one gets to physics the more one can empathize with the common notion that abstraction is not enriching, but in some sense devaluing. We are taken into an intellectual pattern of experience where nature is understood using the formal sciences of logic and mathematics with remote relationships to experience via complex instruments that few people understand. In understanding the universe of physics the palpable universe seems to slip away.

In moving into the human sciences one would expect the situation to improve. It does in the sense that a wider range of phenomena are considered. But as the sciences develop there is an increasing need to understand using abstract models which are not yet sufficient for completely understanding the subject matter. This means that sociologists, political scientists and economists, for example, do not yet fully understand what they are studying, which implies that the efficacy and practicality of their insights is limited. Thus, to the politician and business man who need to survive in and deal with concrete situations their recommendations can seem well-intentioned but unrealistic. As the models develop, we would expect the situation to improve. But it will only improve if the models get better and if we fully understand that we need to apply them concretely. What does this mean?

It means avoiding the mistakes of the mechanist determinists and, as we shall see, some cognitive scientists and any reductionists. The first is not understanding the inherent limitations of abstractions as ideal. The second is not applying them concretely. Instead of using them a priori to understand situations in general, one needs to apply them in particular situations via mediating insights that discover where they are relevant and where they are not, and via mediating judgments where we determine if what we understand is true in this particular instance. Now, since particular instances can diverge from the general case, there may be no systematic insights that can be applied to mediate between the general and the particular and no set of systematic reflective insights (i.e. as laid out in a set of rules) to guide verification. One can draw on past "experience", which really is particular non-systematic knowledge gained in situations, or rules of thumb for guidance. But we always will need to determine if the prior and the current situation match and if they do not then how the model applies differently in each. So it is the need for concrete insights and judgments that tends to be overlooked in these instances where we tend to take the part (the abstract model) for the whole (the full situation) In the human sciences this means that some type of phenomenological description and hermeneutics needs to be done preparatory to understanding systematically via direct insight as well as in gathering observations and data for statistical analysis. The same skills need to be utilized to perform the observations that yield the data required to verify the understanding reached.

By abstracting from the non-systematic it is possible to conceive of events necessarily following from one another. In turn this leads to a logical notion of relationships. If A, then B based on the relation R. This permits a notion of verification based on logic where the conditions for judgment are the conditions for the existence of what is affirmed. Thus if I know A is, then B must be.

This model gets inverted when it comes to verifying unobservables with representative cognitive models. As noted in our discussion of Husserl's critique of the thing in itself, a representative cognitive model considers experience to be representative of the object experienced. Thus, we do not experience the tree in itself. Rather experience is a representation of the tree. One may recognize that experience as representative also has biological conditions in which case the experience as representative has unobservable biological and "physical" causes.

Let us move to a simpler illustration where a measurement is made of an unobservable via an instrument. Based on the relations of the unobservable to the instrument, in the ideal situation if the instrument displays a certain value then we could claim that it does so because of the unobservable. The unobservable causes the reading. (analogous to objects creating "impressions" on our senses). Thus, if the reading occurs, we can conclude that the unobservable exists. Verification takes the form "If A exists then B exists". B exists. Therefore A exists. The statement "If A then B" is logically true if both A and B are true. However, in the recondite world of logical possibility it also is the case that the statement is true if A is false and B is true.   Thus the existence of B cannot logically imply the existence of A. If the relationship between A and B was that one would not exist without the other existing, then the logical relation would be of mutual implication. The statement would be "A if and only if B". But in that case we would not be dealing with a scientific hypothesis that we were trying to establish via implication. We would be begging the question if we accepted A if B occurred since we already have accepted a link between them.

In factual knowing there is a rational necessity to assent if the conditions for knowing that X is are recognized by us as being met. But rational necessity is not formal necessity. The facts could be otherwise. They just happen not to be otherwise. Fallibilism as a formal possibility is inherent in knowing facts. Events do not follow necessarily from one another. Nor do judgments.

We have outlined the error of necessity getting imported into nature based on the abstractness of the understanding involved and the reliance on logical relations as models for natural relations. Metaphor leads to similar problems. The notion of levels of organization is a visually based metaphor which is misleading in understanding organisms and the relation of the sciences to one another. We will elaborate this point in the next chapter where we will further develop the understanding of an organic whole as both non-systematic and one, or a unity. Then we can understand how the notion of levels of organization is inappropriate for a full understanding of organisms. This will provide the context for introducing the model of the operational situation and understanding its role in consciousness.

A Final Note on Auto and Self Organizing

Earlier we alluded to a distinction between auto and self organizing without explaining the difference. Auto-organizing relies on the nonsystematic diffuse operator supplying the conditions for something becoming itself where what it becomes emerges. Self organizing implies an operator that initiates or provides some control of the organizing.

We have seen that auto-organizing is a type of emergence and becoming whose remote source is the spontaneous interaction of “parts”. Auto-organizing is not an organizing of these, but a coming to be of an organization of them spontaneously. We can consider the physical forces that maintain the unity of atoms and molecules as contributing to their form so that we need to understand atoms and molecules in terms of physics. But these are, in a sense, the mechanisms of combination. They leave open which combinations occur. In the internal environment of the organism which sets the boundary conditions for biochemical reactions, the combinations are bio-chemically and organically conditioned. We can see then that there are two at least two types of complex organization. The first is the spontaneous organization of a whole – i.e. A biochemical and the second is the coordination of processes via the mediation of agents that work like operators in initiating, sustaining and terminating processes. The first type of organization is immediate. The second is mediated. A third would be mutually mediating. When we get the point of having a self these types repeat as self-mediating and mutually self-mediating. Mutually self-mediation can occur in my own development as I appropriate unknown aspects of myself (interactions within myself with myself as known and myself as other) as well as in interaction with others.