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Source: *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association*, Vol. 1970 (1970), pp. 257-272
Published by: The University of Chicago Press
Stable URL: http://www.jstor.org/stable/495768
Accessed: 01/09/2010 16:03

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ARTICULATION OF PARTS EXPLANATION IN BIOLOGY AND THE RATIONAL SEARCH FOR THEM

With the realization that the grounds upon which an hypothesis comes to be formulated can be considered separately from the grounds upon which it is accepted, it has become popular among some philosophers and scientists to claim that although it may be of psychological interest to understand the genesis of hypotheses, there can be no logic of search or discovery. While it is unclear exactly what is meant by the claim that there can be no logic of search, it *is* clear that this opinion, coupled with anecdotes of Poincaré's sudden solution of a mathematical problem while stepping on a Madrid streetcar, and Kekulé's vision of a snake biting its tail, have left the aura that the generation of an hypothesis is as mysterious as a Gestalt shift in perception of a figure. Perhaps because Gestalt shifts seem to occur without a processes of reasoning, but in some sense, spontaneously, the use of such perceptual shifts as models of hypothesis formation have lent support to the claim that there can be no logic of search. To a practicing scientist, the image of the startling 'shift' and insight might seem overly flattering of the scientist's genius, and the actual generation of hypotheses seem more reasonable and less mysterious. Some of the ways in which the generation of an hypothesis is a rather reasonable affair will be discussed below in conjunction with an effort to examine some of the features of what I am calling articulation of parts explanations, as they occur in biology.

Typical explanations in biology exhibit the manner in which parts and processes articulate together to cause the system to do some particular thing. Examples include accounts of the cardiovascular system, protein synthesizing system, endocrine system, etc. I do not wish to say that articulation of parts explanations occur only in biology, or are the only form of explanation utilized in biology, merely that such explanations are prevalent in biological sciences and exhibit interesting properties which I wish to discuss.

To refer to some types of explanations as articulation of parts explanations suggests that some explanations are not. I suggest that when a thing is seen as consisting of a single part, or as a continuum, then explanations of the appropriate aspect of its behavior will not exhibit how parts work together. For example, Newton's first law of motion does not exhibit how parts of a system work together, for there is but a single part – a particle in rectilinear motion. Maxwell's field equations treat an electromagnetic field as a continuum, not as a second order infinity of points. Further, some behaviors of a given system may require an explanation by reference to the interworkings of its parts, while others of its behaviors may not. For example, the manner in which a gasoline engine falls is predictable from an account of the engine as a mass without discriminated parts.

I wish to pursue the following theses:

1. An organism may be seen as doing indefinitely many things, and may be decomposed into parts and processes in indefinitely many ways.
2. Given an adequate description of an organism as doing any particular thing, we will use that description to help us decompose the organism into particular parts and processes which articulate together to cause it to behave as described.
3. For different descriptions of what the organism is doing, we may decompose it into parts in different ways.
4. The use of an adequate description of an organism seen as doing a particular thing to guide our decomposition of it into interrelated parts and processes, and indeed part of the logic of search, is intimately connected with the sufficient conditions for the adequate description. In particular, we can use the sufficient conditions to generate a cybernetic model showing how symbolic parts might articulate together to cause a symbolic version of the described behavior.
5. We can use such a cybernetic model to help find an isomorphic causal model showing how presumptive parts and processes of the real system might articulate to cause the described behavior.
6. Since there may be more than one set of sufficient conditions for the adequate description of the behavior, more than one cybernetic model to account for the behavior may be constructed. Such different cybernetic models will not be isomorphic, and each leads us to decompose the system in a different way. Hence, not only are organisms decomposed into parts to yield articulation of parts explanations in different ways for *different* adequate descriptions of the organism seen as doing diverse

things; but different tentative decompositions can be made of the system seen as doing any one thing, through the use of the diverse sets of sufficient conditions of that adequate description.

7. A successful decomposition leads to an articulation of parts explanation of how the system does what it is seen as doing.

8. We not only use views of what a system is doing to help decompose it into parts, we use information about parts to synthesize new views of what a system is doing.

9. The descriptions of parts and processes of one decomposition need only be compatible with and not deducible from the descriptions of parts and processes of a different composition.

10. There *need* be no 'ultimate' decomposition such that all other decompositions are deducible from it, although there may be such an 'ultimate' decomposition.

1. Perhaps the first point to be made is that there is no uniquely correct view about what an organism is doing. But, in order to achieve an articulation of parts (henceforth, *A* of *P*) explanation about an organism, we must, perforce, be explaining how the parts and processes articulate together so that the system does something. To begin studying such an object, we must come to some initial view about what the system is doing; literally, a view of what is happening. Consider that an organism may be viewed as: a self-replicating system, a developing individual, a parent with similar appearing offspring, a member of an ecosystem, a system exhibiting circadian rhythms, a member of an evolving population, an open thermodynamic system maintaining a locale of low entropy, etc.

Now, not only are multiple views about what a system is doing possible, but also any system may be decomposed into parts in indefinitely many ways, and for any such part, it too can be seen as doing indefinitely many things. Our questions concern the character of the diverse possible decompositions into parts and the relations between parts within one decomposition, and between diverse decompositions.

2. I suggest that we use an adequate description of a view of what a system is doing to help guide our decomposition of the system into a particular set of parts and processes which causally articulate together to cause the system to behave as described. A view of what a system is doing sets the explanandum and also supplies criteria by which to decide whether

or not a proposed portion of the system with some of its causal consequences is to count as a part and process of the system. Specifically, a proposed part will count as a part of the system if it, together with some of its causal consequences, will fit together with the other proposed parts and processes to cause the system to behave as described. In general, it is not possible to decide that a single proposed process is to count as part of the system in isolation from decisions about the adequacy of the suppositions about the remaining parts and processes. Parts and processes are accepted more or less jointly, and with them, the adequacy of a particular articulation of parts explanation in which just those parts and processes are seen as fitting together to yield the behavior in question. Other causal consequences of these parts are then considered irrelevant. I will call such a decomposition of a system a conjugate, coherent decomposition, for it is conjugate to a particular view of what the system is doing, and coherent in that it provides an articulation of parts explanation of how the system does whatever is specified in that particular view of it.

3. Clearly, distinct views of what an organism is doing may lead us to decompose it in distinct ways. Our account of an organism as a device exhibiting circadian rhythms picks out different parts and processes from an account of the effects of chromosomal crossing over on population genetics.

4. I wish to argue that part of what might be called a logic of search involves our use of the sufficient conditions of an adequate description of a view of what an organism does to help find a cybernetic model of the phenomenon, and thence, a causal model. I will consider first a hypothetical case of tissue reaggregation, then an actual description of gastrulation in the chick, and hypotheses generated to account for these phenomena.

Hypothetical Example

Suppose we note that the cells of a sponge can be disaggregated and then allowed to reaggregate, and that, upon reaggregation they always form a particular three dimensional structure in which different specific cell types are at specific loci relative to one another. Sponges are deformed by currents in the water, and we will consider that an adequate description of this hypothetical sponge need only describe cell movement and specify which cell types have which cell types as neighbors, and in which directions, and which cells border internal and external lumens in the final structure. Note that the specification of cell types is made on the basis of some theory, here the cell theory. The observation that the cells reaggregate constitutes a view about what the system is doing, and sets us a question.

There may be more than one set of sufficient conditions for the truth of any description. By sufficient condition I here mean a description of a state of affairs such that from this description and with no further empirical information, the initial description may be deduced. I shall refer to such a description as a descriptive sufficient condition.

Let us assume that in our hypothetical aggregate, each cell type has either no cell as a neighbor in some directions, or only specific other cell types. Thus, we may assume that a description of these restricted adjacency relations, plus an account of the numbers of each type of cell, constitute descriptive sufficient conditions from which, with no further empirical information, we might deduce the initial adequate description.

We can, however, find a different set of descriptive sufficient conditions for the initial description. If the reaggregate is located in a three dimensional coordinate system with some particular cell taken as the origin, then the specification of the coordinates of each cell, and its cell type, is surely a descriptive sufficient condition of the original description, from which that original description can be deduced. I want to argue that each such set of descriptive sufficient conditions can be utilized to help find a model of how the cells manage to reaggregate, and that models derived from different sets of descriptive sufficient conditions pick out different putative parts and processes interacting in different putative articulation of parts explanations.

The power of the strategy of search I shall discuss rests on three features, two logical, one contingent. (1) If a process can be found which is causally sufficient to bring about the state of affairs described in the descriptive sufficient conditions then that process necessarily is causally sufficient to bring about the state of affairs described in the initial description. (2) Any initial description has multiple sets of descriptive sufficient conditions. (3) It is a contingent fact that very often, the ease of finding a causally sufficient process for one set of descriptive sufficient conditions is greater than for other sets of descriptive sufficient conditions. Indeed, sometimes a process to bring about a descriptive sufficient condition is suggested in a transparently obvious way by the descriptive sufficient conditions themselves. The sense of transparently obvious will be brought out below.

The first step, then, in utilizing a descriptive set of sufficient conditions is to suppose that there is a process which is causally sufficient to bring about the state of affairs referred to in the descriptive sufficient conditions. In the hypothetical aggregate we are considering, suppose we are currently using the descriptive sufficient conditions in terms of restricted adjacency relations among the different cell types. We then suppose a process which brings about just these intercell boundries. A particularly obvious choice of process is to assume that only these specific intercell boundaries form bonds between the cells. Since cells move during reaggregation, then remain properly juxtaposed, we also suppose a process which causes movement relative to one another among the cells until an allowed boundary is formed, when relative movement of the two cells stop. These hypothetical processes may now be linked, or articulated together to show how the state of affairs described initially might come about; specifically, cells move about until they come into contact with the appropriate neighbor cell type, when stable bonds are formed, relative movement stops, and the final architecture of the aggregate is generated.

At this stage the model is what I will call purely symbolic, or cybernetic. As yet, no actual causal mechanism is suggested. The cybernetic model provides a set of rules such that a set of symbols behaving as prescribed by the rules, will generate a form isomorphic to the cell assembly. The cybernetic model asserts that if causal mechanisms can be found such that only restricted bounderies form stably and relative motion of cells then ceases, then the observed behavior will occur in the aggregate. The central criterion of adequacy of such a cybernetic model is sufficiency. That is, it must be true that a set of symbolic components behaving as described by the rules in the model would, in fact, result in an aggregate isomorphic to the cell aggregate. Note also that the cybernetic model, while not yet suggesting actual causal mechanisms, exhibits the manner in which the processes of the parts of the system must articulate – namely by mediating the formation of restricted kinds of intercell boundaries. Thus, the cybernetic model, and indeed the adjacency descriptive sufficient conditions themselves, already begins to indicate the relations that are to exist among the parts and processes of the system; furthermore, the cybernetic model coupled with our current knowledge about cells begins to suggest what sorts of causal mechanisms are required. Specifically, mechanisms are

(For an explanation of these figures see text on page 265.)

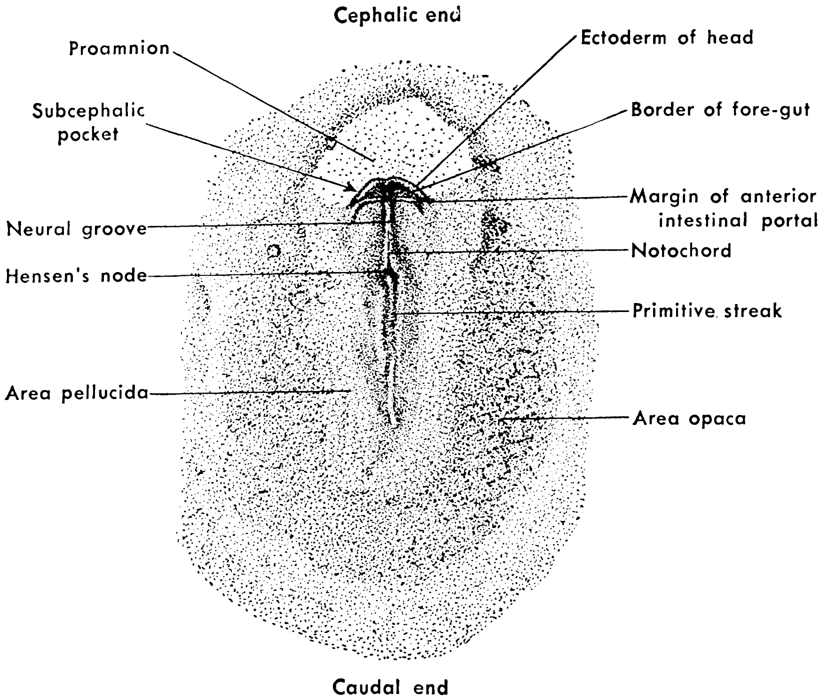

Fig. 1a. 20 hr chick embryo, dorsal view. Redrawn from Patten.

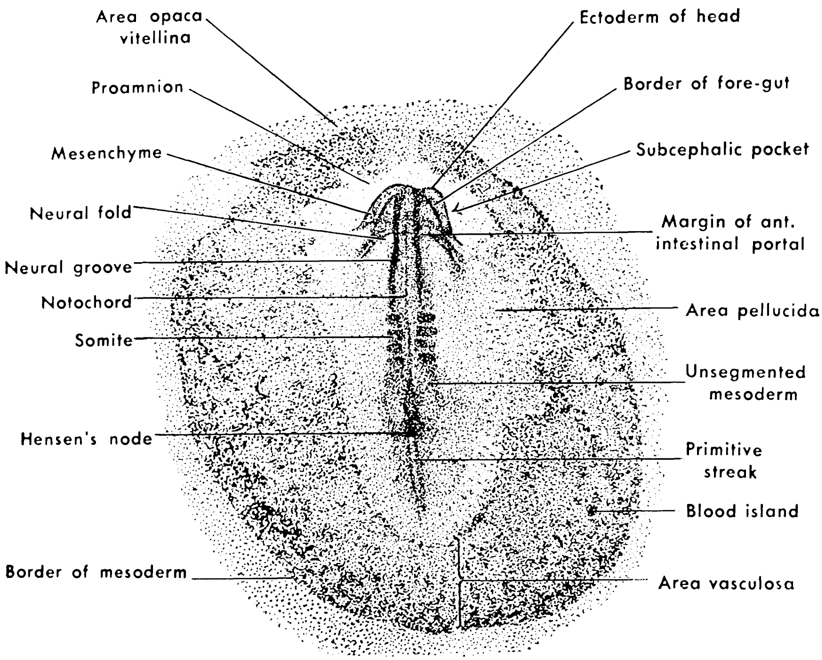

Fig. 1b. 24 hr chick embryo, dorsal view. Redrawn from Patten.

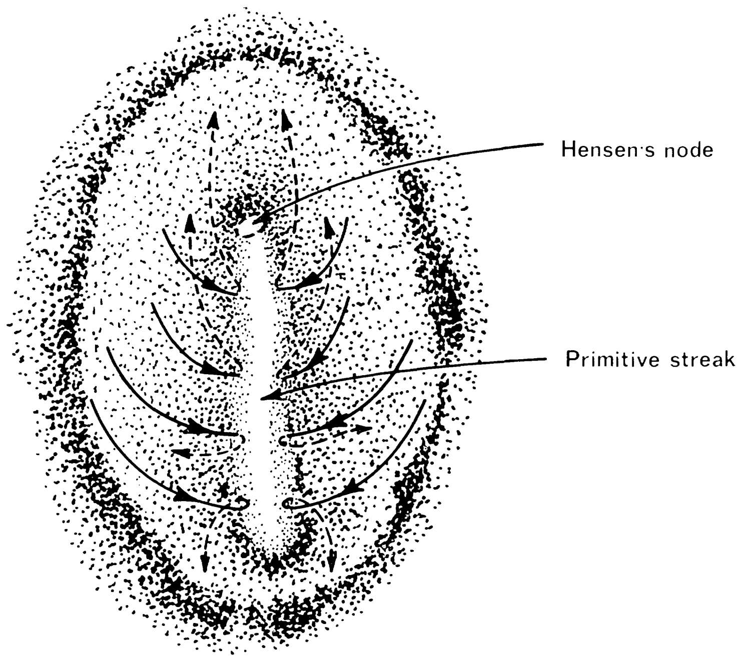

Fig. 1c. Schematic drawing of epiblast cell movement, solid arrows, and movement of mesodermal tissue, dotted arrows.

required which will create specific intercell boundaries, and not allow other intercell boundaries to form. We do not know yet what particular causal mechanism achieves this, but we do know that causal consequences of putative parts of this system which do not yield specific intercell boundaries may be treated as irrelevant causal consequences of the parts of the system. Those causal consequences, that is, processes, will not be regarded as processes of the system, but as irrelevant behaviors.

The descriptive sufficient conditions of the initial adequate description speak, if you will, in the imperative mood. They are an injunction to the scientist to direct his attention to those conditions, for around them it should be possible to build a cybernetic, and later a causal, model to explain the phenomenon. It is at least partially because the sufficient conditions can be used to generate a cybernetic model that the generation of hypotheses is a rather reasonable process.

5. With the cybernetic model in hand, and background knowledge about cells, we can now search for the kind of casual processes which are likely to cause restricted boundary relations – say specific molecules on the membranes of the different cells, each of which only interlocks with the appropriate others. With the suggestion of a specific set of causal mechanisms, the model has become an hypothesis requiring verification. If verified, it will specify which processes – that is, which of the many causal consequences of each of the portions of the system – are to count as processes of the system, and which are irrelevant to this particular account. With the verification of the hypothesis we will have achieved an articulation of parts explanation of how cells manage to reaggregate. Until we are confident of the entire *A* of *P* explanation, we may remain unsure about the claim that any particular process is to be regarded as a process *of* the system.

A cybernetic model is used to help find a causal model isomorphic to it. More than one causal model might be suggested, each isomorphic to the cybernetic model and to one another. The sense of isomorphism intended may be exemplified by supposing that one has designed, on paper, an adding machine. The design is a flow chart of operations performed by as yet symbolic devices. Now an actual machine realizing this design might, for example store numbers by filling and emptying water tumblers, or filling and emptying capacitors. The different physical realizations would be isomorphic to one another and the cybernetic model by virtue of the fact that the parts and processes of one machine can be put into one correspondence with the appropriate part and processes of the other real machines or cybernetic design model. While isomorphic in this sense, the causal mechanisms by which the different physical machines realized the cybernetic design model would differ, and would be described by different causal laws. In the example of the cell aggregate, many different causal means of forming only restricted adjacency relations might be considered.

6. Different sets of descriptive sufficient conditions of the same initial adequate description can be used to generate different, non-isomorphic, cybernetic models, and in turn, non-isomorphic causal models which decompose the organism into different putative parts and processes. For example, specification of the coordinates of each cell, and its cell type, in a three dimensional coordinate system with one cell taken as origin, was a set of descriptive sufficient conditions for the initial adequate description. Utilizing this, we build a cybernetic model by supposing a process which is causally efficacious in generating the state of affairs referred to in the descriptive sufficient condition. In that descriptive sufficient condition, each cell is specified in a coordinate system. A particularly obvious choice of process suggested by this set of sufficient conditions is that there *is* a coordinate system in the reaggregate with some cell as origin, and that each cell 'knows' where it is in the coordinate system and goes to the correct place. We then suppose that an origin cell somehow elaborates a coordinate system and that cells have some means of 'knowing' their location. From this cybernetic model, we make use of knowledge about cells to suggest causal mechanisms and achieve an hypothesis.

Note that the parts and processes specified in this description, and this cybernetic model, cannot be put into one to one correspondence with the parts and processes of the adjacency cybernetic model; here, distance measuring from an origin cell is a process of the system, and formation of restricted types of boundaries between adjacent cells is an irrelevant behavior of the cells. The two cybernetic models are not isomorphic, neither are those causal models which are isomorphic to each, isomorphic to one another across cybernetic models.

7. A successful articulation of parts explanation distinguishes between irrelevant causal consequences and important causal consequences of a

part, thus the explanation not only accounts for the behavior of the whole, it supplies a view of what it is that the parts themselves shall be seen as doing from among the indefinitely many possible things each part might be taken to be doing.

We now consider a more realistic example of hypothesis formation concerning gastrulation in chick embryogenesis (see figures). In its early stages, the chick embryo consists of a double layer, roughly oval, patch of cells on the yolk. The superficial layer is called the epiblast, the layer next to the yolk is the hypoblast. During gastrulation, cells of the epiblast move in an arc backward and medially, on both sides of the patch of cells, and condense in the midline to form the primitive streak. There, the cells sink below the epiblast to the region between the epiblast and hypoblast, and the cells spread laterally and forward between the two initial layers, forming a third, mesodermal layer. Medial flow of the epiblast, invagination, and lateral flow of the mesoderm occur with bilateral symmetry along both sides of the primitive streak. At the head, or rostral end of the primitive streak, a small mass of cells known as Hensen's node forms. With time, the primitive streak becomes shorter, and Hensen's node is carried bodily backward toward the tail, or caudal end of the primitive streak. In the region anterior to Hensen's node, epiblast cells are not moving medially, nor are cells sinking below the epiblast and migrating laterally. That is, Hensen's node is the anterior-most locus in which cells are invaginating to form the mesodermal layer, and as Hensen's node regresses backward, the primitive streak which is the region where invagination is occurring, becomes shorter. Some time after the node regresses, condensations of the mesodermal cells into aggregates to form somites occur bilaterally along both sides of the line that Hensen's node has followed during its regression; that is, on both sides of the line where the primitive streak was prior to its regression. Our problem is to explain the occurrence of bilaterally symmetrical somites in just the loci in which they occur.

Let the foregoing description be considered an adequate description. A different set of descriptive sufficient conditions might be: (1) a description of cell movements as given above. (2) The addition that somites condense only after invagination (sinking below the epiblast) and the other medial and lateral movements of gastrulation have ceased; and further, that somites condense only in those cells which were the last to invaginate to the mesoderm. This description is a sufficient condition of the initial description since it includes the claim that lateral cell movement of the mesoderm stops when invagination stops, and we can therefore deduce from this new description without further empirical information that somites form in bilaterally symmetric lines adjacent to the line of the now regressed primitive streak, as described in the initial description.

Processes capable of bringing about the state of affairs described in these new sufficient conditions will be processes capable of causing the state of affairs initially described. In addition to description of cell movement, this new set of descriptive sufficient conditions refers to: (1) formation of somites only after cessation of movement, (2) aggregation of initially disperse mesodermal cells into local aggregates; (3) the occurrence of these aggregates only among the last cells to invaginate. We need to find processes to bring about these effects. That is, we suppose processes by which (a) cessation of movement allows or causes mesodermal cells to aggregate; (b) mesodermal cells aggregate; and (c) only the last to invaginate aggregate. The descriptive sufficient conditions themselves suggest rather obvious processes. If we suppose there is some process by which mesodermal cells tend to aggregate, then movements of gastrulation might overcome the tendency to aggregate, thus cessation of movement would allow aggregation to occur. We now need a process by which there is a tendency of mesodermal cells to aggregate. A new descriptive sufficient condition for the initial description of aggregation is that originally, mesodermal cells are fairly dispersed, but move about, and when they come together, they stay together. We suppose a process causing the state of affairs described by this new descriptive sufficient condition to occur, say that mesodermal cells are sticky and attach to one another. We now need a process to cause only the last cells to invaginate to aggregate. Since we are to account for aggregation by mesodermal cells sticking together, this process must either be strongest, or most effective among the last cells to invaginate. If we suppose that mesodermal cells elaborate a diffusible 'sticky stuff', then epiblast cells will absorb sticky stuff as they migrate medially over the laterally migrating mesodermal cells. Epiblast cells which have traversed a greater number of mesodermal cells will be stickier than those which have traversed fewer. Epiblast cells arriving at the primitive streak later will be stickier than those arriving earlier, thus the last to arrive will be the stickiest, and the aggregation will occur in the proper place.

We now have a cybernetic model utilizing the three processes; that movement disrupts the formation of aggregates, that mesodermal cells tend to stick together, and that countercurrent movement of the cell layers will concentrate diffusible 'sticky stuff' near the primitive streak rather than laterally. This model can now be used to generate a causal model in which, for example, the 'sticky stuff' receives a molecular interpretation of some kind. As in the previous example, the descriptive sufficient conditions of the initial adequate description of the entire process and portions of it, have served as injunctions to direct attention in particular ways in order to build an hypothesis. And the formation of the hypothesis does indeed seem a rather reasonable affair, open to the judgement of having been done stupidly or well.

As in the previous example, differenet descriptions which are sufficient conditions for the truth of an initial description can yield radically different models. For example, somites may also be described as forming in those mesodermal cells over which Hensen's node has passed. This, coupled with a description of cell movement, is sufficient to deduce the initial description. It leads to the supposition that Hensen's node somehow causes or induces the underlying mesoderm to differentiate into somites. As in the previous example of cell reaggregation, models derived from the two different descriptive sufficient conditions are not isomorphic; each picks out parts and processes in a different way. In the last model, Hensen's node is the crucial part which induces somite formation in the underlying mesoderm; in the former model, Hensen's node is an incidental part of the mechanism having no bearing on the formation of somites. Slightly more advanced forms of the two hypotheses are currently under experimental investigation.

We need now to ask what criteria we utilize to judge whether an initial description is adequate, and what information we use to guide our choice among indefinitely many descriptive sufficient conditions and possible cybernetic and causal models.

In the initial description of the cell reaggregation, and of chick gastrulation, many things which occurred were left undescribed. For example, motions of enzymes within cells, the color of the container in which the system was maintained, and the brownian motion of ions in the medium were not described. Surely, an adequate initial description is already a highly selective description based on our background knowledge about the sort of system and process we are concerned with. The initial description is made in terms of facts and factors we have reason to believe will be the relevant facts and factors, on the basis of our current knowledge and theories. Of course, the initial description may turn out to be inadequate because our suppositions about what is relevant may be incorrect.

There are several interrelated ways in which we use background knowledge to help choose from among diverse descriptive sufficient conditions and cybernetic models those which commend themselves for further serious effort. On the basis of background information, we know a reasonable number of different processes which are, so to speak, stock in trade. For example, cells adhering to one another is such a process. These processes are simple in three senses: (1) They are well known and understood, thus intuitively simple; (2) Many plausible causal mechanisms to realize the process are known or can be supposed, indeed it is just because there are so may causal mechanisms by which cells can adhere to one another that the process 'cells adhere' is very familiar and stock in trade; (3) These processes are simple in the sense that it is by articulating together more than one of these well understood processes that we seek to explain more complex processes. For example, in the hypothetical cell reaggregate, it was permissible to suppose a process 'by which just these cell boundaries form bonds,' for specific bonds between entities is a process which is simple in the specified sense. However, in the chick gastrulation case, the supposition of a process by which cells along the line of the primitive streak, but not laterally, hapened to be the ones to aggregate, would be inacceptable, for this is just the sort of case where we want to see from *other* simple processes, how this complex process might occur.

We therefore choose among the diverse descriptive sufficient conditions those for which we think we can put together a cybernetic model articulating such simple processes. Even if we achieve an articulating cybernetic model, that model might yet be considered implausible for two quite different sorts of reasons. First, the causal mechanisms by which the cybernetic model might be supposed to be realized might be considered implausible in the system under study. Second, even if plausible causal mechanisms might be imaginable, it may be that the cybernetic model demands, in some sense, too much machinery, and it may be implausible to think the system behaves as described initially by such complex means. For example, a descriptive sufficient condition for the initial description of chick gastrulation in terms of a coordinate system is possible, and from it one can create a cybernetic model in which the chick embryo elaborates a coordinate system and cells 'know' where they are and go to the right places. Although causal mechanisms which are plausible might be imagined, the entire construction is likely to be considered an implausibly cumbersome way for a chick to go about gastrulating.

Finally, it must be added that it may not be possible to find a cybernetic model for any of the descriptive sufficient conditions of an initial description which have so far been investigated, for there is no guarantee that, with the currently acceptable set of simple processes, a cybernetic model *can* be formulated. When we are unable to find such a model, one of the most obvious strategies to take is to reexamine the phenomenon we wish to explain and alter our initial description by including new data now hoped to be relevant.

8. Having discussed ways in which we utilize a view of what a system is doing to achieve an articulation of parts decomposition into parts and processes interrelated in particular ways, we now turn to ways in which we utilize information about parts to synthesize new articulation of parts views of what the whole is doing. First, it is clear that new information about a part picked out in an old decomposition of the system can lead to new views of what the system is doing. For example, Harvey's discovery that the blood circulates led to a new view of what the heart, specified on old anatomic grounds, does. The current discoveries that cells and organisms exhibit circadian rhythms, and are, in general, temporally organized, is the focus of debate about the 'significance' of such rhythms. The efforts of this debate are to synthesize a new view of what an organism is doing – essentially to be a timekeeper of some sort. The points to notice about such new syntheses are that, in general, the new synthesis may decompose the system in a new way, cutting across parts specified in an old decomposition. For example, the endocrine system cuts across the old anatomic decompositions; the view of an organism as an open thermodynamic system maintaining low entropy cuts across the decomposition of it as a circadian system.

An important feature of achieving a new synthesis of what a system is doing is that the new view may require no new verification. It may be that true descriptions of behaviors of parts picked out on an old decomposition have accumulated, where these behaviors are irrelevant to the behaviors of the parts which linked them into a system in that old decomposition. It might then be realized that these 'irrelevant' behaviors can be interrelated to achieve a new view of what the system is doing. Since the truth of the descriptions of these irrelevant behaviors is supposed to have been adequately established already, the adequacy of the new composition may not require verification. Of course, the new composition will have *further* consequences which require verification. The 'irrelevant' behavior might have been established in two ways: It may be that, given one description of what the system is doing and a conjugate decomposition into parts and processes, the true descriptions of what the parts are doing, coupled with current theory, may entail the truth of descriptions of other 'irrelevant' causal consequences of the parts. These other causal consequences may be linked together to yield a new synthesis of what the system is doing which would pick out new features of the system and provide an *A* of *P* explanation. The truth of the explanation would be adequately established by the validity of the deductions from the true initial description of the system, and the adequacy of current theory about the stuffs of which the parts were made. On the other hand, we may merely have discovered 'irrelevant' causal consequences of parts on an old decomposition, and established the descriptions of the irrelevant causal consequences by observation, not by deduction from the old descriptions and current theory. These independently established claims about irrelevant behaviors might be linked together to achieve a new composition, or view, of what the system is doing. In either case, the adequacy of the new view does not require verification in the sense in which hypotheses are normally understood to require verification. Of course, normally new compositions often do assert claims about behaviors of parts which are not yet established, and these do require verification. Thus, achievement of a new composition *can* occur without having to reexamine the empirical world; the new composition focuses attention on new features of the system and, presumably, provides a new *A* of *P* explanation of the newly noted behavior. A new behavior is seen as calling for an explanation.

9. We have noted that different views of what a system is doing yield different decompositions of that system into parts and processes. The foregoing discussion has also indicated the ways in which the various true claims made in the diverse decompositions may be related across

decompositions. The claims must, eventually, at least be consistent with one another. However, there is no requirement that the claims made in one decomposition need ever be deducible from those made in another decomposition. That is, the claims must eventually be *compatible* with one another, but not deducible from one another. The set of causal laws sufficient to provide an *A* of *P* explanation of the system seen as doing one thing may not include causal laws necessary for the explanation of a second thing the system may be seen as doing. Thus, the various accounts may proceed independently from one another, with the restriction that they must all, eventually, be non-contradictory.

10. A final point. It may be asked whether there are not preferred views of what an organism is doing, for example, living. I am willing to grant that some views of what an organism does are currently seen as more central to the defined interests of biology, but am not willing to agree that all possible views of what an organism may be seen as doing must, in some sense, be seen as extensions of, versions of, or reducible to those preferred views. To insist, whatever an organism may be seen as doing, that that feature of it is an aspect of a particular view of the organism, say being alive, may be mistaken in each of several ways. It might be the view that only the preferred view of what the organism is doing is to be allowed. It might be the view that whatever happens in an organism is causally necessary for the organism to, e.g. live. Now this claim is almost certainly either false, or an analytic claim masquerading as an empirical one. It might be the view that if the organism is made of just those materials with those particular causal consequences accounting for how it manages to live, then these particular materials have also just the other (indefinitely many) casual consequences. Thus, if the system is to do what it does – e.g. live – then it must do these other things as well. While this version of the claim is true, it does not establish that all views of what a system is doing must be able to be brought under one view of what it is doing and deduced from claims explaining how it does that particular thing. For the truth of the claims on the different accounts need only be compatible, not deducible, from one another. Thus, while the argument above is valid, it does not establish that the diverse account of how the system does the diverse things it can be seen as doing, need be deducible from any one account. The accounts may proceed independently with the restriction that all must eventually be jointly compatible.

Thus, it seems we must admit that many of the features of organisms which we seek to explain are incidental to any particular view of it, even to 'being alive'. Articulation of parts explanations of any way be logically independent, in the sense of not being deducible from many or all the others. There is no reason to restrict the features of organisms we will seek to explain. We can insist that we achieve articulation of parts explanations rather than compilations of true descriptions which fail to articulate. Finally, while we can and do form new inclusive views of what an organism is doing which joins several earlier views in new and rewarding ways, there seems to be no reason whatsoever to insist that all possible views of what an organism is doing and all possible true articulation of parts explanations, need ever be brought under some overarching, ultimate view of what the organism is 'really' doing. For there are, indeed, indefinitely many things which an organism can legitimately be seen as doing, and there is every reason to expect biologists to pursue an ever widening ring of puzzles to explain.

ACKNOWLEDGEMENT

The author wishes to thank Drs. Dudley Shapere and David Hull for helpful criticism.

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