directed OPPORTUNITY, directed IMPETUS
NEW TOOLS FOR INVESTIGATING AUTONOMOUS CAUSATION
(WORKING PAPER)

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ABSTRACT

How natural behaviors actually work is often counter-intuitive. That is especially true of autonomous behavior systems, ones that develop original organization in the midst of the events they carry out. We can't commonly know much about their causal organization because it is original to themselves and internalized. The dual stream model of causality presented here is part of a general technique for investigating how autonomous systems are organized and what animates their development.

Though the technique is logical and useful, both for investigating autonomous systems and for making certain types of firm predictions about them, it also challenges our normal ways of understanding things. It directs attention to concretely observable 'motive processes' (autonomous causal system building processes) more than external determining causes, and maps the environments in which they operate in terms of a multi-level network of active and passive enabling causes. Mathematical models of behaviors, both those based on 'natural laws' and on isolated projections from previous measures, are recognized as useful references and predictors but not as legitimate representations of what autonomous behavior systems are or how they actually operate.

A reasonably descriptive name for the technique would be 'autonomous systemization study'. The 'rosetta stones' for its interpretation and use are process events that display systematic organizational growth. These systems may not all be 'living' in the normal sense, but they are not at all 'lifeless'. They are the source of most coherent behavioral animation.

In practical application the technique has guided the development of a verifiable axiomatic proof regarding a chaos generating autonomous dynamic of the economic system, i.e. that: "the automatic compounding of investment returns will bring about ... a majority failure of investments" (Henshaw 1985). One hope is that producing such firm and dramatic results will help to generate a greater acceptance of the study of near living systems as a legitimate and fruitful subject of scientific research.

I. INTRODUCTION

THE SUBJECT: The following presents part of the general method that the author currently uses for investigating exactly how autonomously organized physical event processes develop and operate. It involves an empirical technique for exploring how the causes of events become systematically internalized within event process as they develop.

The study method can address the autonomous behaviors of social, political or economic systems as well as of weather systems, biological organisms and chemical, fluid dynamic, electro-magnetic and potentially even subatomic systems. It applies to animated autonomous system individuals in general, both those in which people participate and those which occur within and around us. These autonomous system individuals are things that people can potentially steer, stimulate, confine, disable or avoid, etc., but will never plausibly be able to fully understand or literally control. They're the things that operate autonomously.

The development of this investigative technique was based on the simple, but rather demanding, initial presumption that there are no operative abstractions anywhere in nature, except in the minds of human observers. Thus, it is presumed that natural behaviors are themselves the physical process of conception, not a reflection of it, and that only what is actually going on in any circumstance is part of how it is taking place. The subject here is the coherently animated things of our world, and they themselves are taken to be the only accurate representations of how they work. No set of evidence is accepted as complete and no initial evidence is taken to be incidental. No laws or equations or other mental abstractions of any kind are considered as part of the autonomous individuals or their behavior, only the concrete things and processes themselves.

A curious feature of natural perception is that our minds are the actual generating source of all the images we see, and that the relationships we perceive to exist between things in our world are actually perceptual relationships between our images of them. Here it is presumed that an observer never actually sees the subjects of their investigation, or their interrelationships, but only generates mental references to them. Whether or not one sees one's images as referential or representational has a very substantive impact on one's understanding of autonomous systems and their behaviors.

The technique for investigating physical processes to be presented here is a direct observation approach. As such it follows more on the methods and example of archeology, botany or anthropology than on those of physics. It is basically a disciplined method of record keeping concerning the developmental life cycles of natural physical process events. Understanding it is perhaps easier from seeing how it is applied than from explanations, so the reader might first go to the example in following section '4.' and then return to this introduction.

RELATED APPROACHES: Quite a number of approaches to the study of systems have been developed over the past 30 or 40 years. This one stands on what one might call the 'serious' side of general systems 'wholism', offering a critically empirical 'vitalist' perspective. It also has specific similarity to various more technical systems inquiry techniques including: 1) *catastrophy theory* (see Thom 1972), in the use of a general cryptic cypher for dynamic events, to 2) *hierarchy theory* (see Allen and Starr 1982), in the use of questions about nesting organizational levels and causal relationships, to 3) *living systems theory* (see Miller 1978), in the concern with universal physical functions, to 4) *reconstructability analysis* (see Cavalo and Klir 1981) in the heavy reliance on empirical measures and observations, and to 5) the *theory of dissipative structures* (see Schieve 1982) and the *theory of dynamical systems; chaos theory* (see Campbell & Rose 1983), in the focus on situations of organizational instability and sensitive dependence on initiating conditions. Any or all of these systems study approaches are considered to be valuable companions to the use of the technique presented here

2. BASIC CONCEPTS

POSITIVE SELECTION: In some ways the approach here is most like an extension of the *eolithic design* concept of discovered purpose in natural invention presented by David Hawkins, (1968). The term comes from the name 'eolith' which is given to the found objects that became used as tools prior to the intentional design of tools at the dawn of the stone age, "stones picked up and used by man and even fashioned a little for his use". The concept offers a positive alternative to the idea that evolution is guided only by the natural selection of random variations on previous structures.

The circumstantial availability and initial haphazard use of eolithic tools might positively relieve or stimulate other activities that, in turn, produced situations in which the potential for the 'rediscovery' of tool use is greatly enhanced. If the innovation is reliably rediscoverable, it could become part of a whole complex of entirely new and substantially modified processes, structures and organizations. The creation of that new complex then comes to have been the 'purpose' of discovering the tool and what establishes it as having been a 'tool'.

The concept of such accidentally initiated, and then positively developed and retained complex innovations is what is used here in place of the classical notion of 'random mutation', and could be generically refered to as 'eolithic mutation'. The idea that innovations must stand up to the test of time to become lasting ones is certainly valid and valuable, but it is insufficient for saying where innovations come from to then be tested. The modern theory of natural selection still essentially holds that the properties of evolved systems appeared for later 'testing' as the result of random single variations upon previous complex organizational structures (see Conrad 1983). This says no more about where nature's innovations come from than that 'they just happen', and is also insufficient.

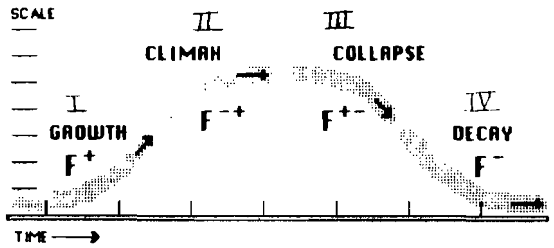
That proposal also strongly suggests that the people offering it have never tried randomly altering and testing a complex structure one part at a time (like the parts of their own car) to see if it became improved. If you're going to make improvements in anything that is complexly interconnected it is quite necessary to make a large number of coordinated changes before the new order can sustain even the most minor kind of test. It is not just a human frailty that we have to work with things that way, but inherent in the nature of complex interdependencies.

Natural variation in processes and structures, the evidently inherent 'wobble' that exists at various levels in virtually all dynamic behavior, may well have great functional importance in systems. It is just not likely to be, as Conrad (1983) and others suggest, the sole source of coordinated system innovations. The question, of course, remains, how do complex and seemingly purposeful natural design processes take place in the absence of any apparent preconceived design or planning.

As already indicated, the proposal here is that successful system innovations first get built up, through a dynamically animated discovery process, and only then confront tests for survivability. Evolution is seen as only secondarily influenced by the destructive events of randomization and selective elimination, and primarily the consequence of materially constructive processes. The normal view that constructive evolution somehow occurs in spite of a pervasive 'meanness' in nature is replaced with the view that the capacities to survive harsh conditions originate from natural conditions of reliable 'generosity'.

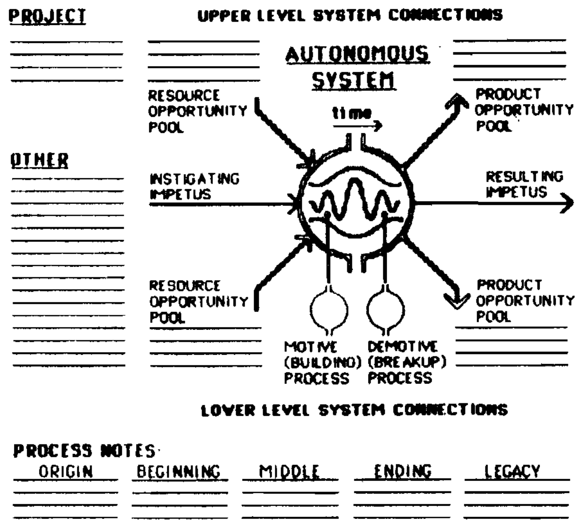
The concept of 'eolithic potential' (the circumstantial presence of 'right shaped rocks') is greatly generalized as used here, and called simply 'opportunity', all of whatever it is that is made use of in the systemization of events and that makes them possible. One of the key ideas is that opportunity comes from combinations of leftover products of other things, 'cast off' products and situations, things simply left 'lying around'. Things that have been *made useless* in the past are what autonomous systems *make use of* in the present.

EMPIRICAL TOOLS: There are two separate parts of the empirical study. One is the accounting of system parts and the opportunities they make use of. The other is the examination of



• INDICATORS OF ORGANIZATIONAL CHANGE •

Figure 1. THE FOUR TRENDS COMMONLY INDICATE PARTICULAR NATURAL PROCESSES OF DEVELOPMENTAL CHANGE. IN TERMS OF THEIR NUMERICAL MEASURES, 'GROWTH' AND 'COLLAPSE' ARE PERIODS WITH NON-VANISHING RATIOS OF CHANGE (EXPONENTIAL) AND 'CLIMAX' AND 'DECAY' ARE PERIODS WITH VANISHING RATIOS OF CHANGE (LOGARITHMIC DECAY).



• BASIC MAP OF AUTONOMOUS CAUSATION •

Figure 2. THIS FORMAT FOR LISTING FEATURES OF AN AUTONOMOUS SYSTEM AND ITS OPERATING CONTEXT HELP TO RECORD AND FRAME THE INVESTIGATIVE PROCESS. OPPORTUNITIES ARE SHOWN COMING FROM AND PRODUCTS GOING TO BOTH HIGHER AND LOWER LEVEL CONTEXTS. THE MOTIVE AND DEMOTIVE PROCESSES ARE INDICATED AS INTERNAL TO THE SYSTEM. IN PROCESS NOTES 'BEGINNING' REFERS TO BOTH GROWTH AND CLIMAX AS 'ENDING' REFERS TO BOTH COLLAPSE AND DECAY

numerical measures of the subject for evidence of four fundamental autonomous organizational development processes.

Figure 1. shows the general cypher used to identify types of aunonomous organizational (and disorganizational) change. Evidence of these curves in some measure often indicates 1) positive causal feedback (F^{+}) and autonomous organizational invention, 2) negative positive causal feedback (F^{-+}) and climax organizational refinement, 3) positive negative causal feedback (F^{+-}) and disorganizational growth, and 4) negative causal feedback (F^{-}) and disorganizational climax. All four of the distinct organizational development phenomena refered to here, in sequence, seem to be necessary phases of the life history of any process that comes into and goes out of existance autonomously.

The evidence of one of these four growth curves is taken as evidence of an autonomous development process in the same way that statistical correlations are taken as evidence of causal relationships. One of the principle uses for these curves is to help identify system motive processes that are self-destabalizing (those underlying 'growth' and 'collapse') As direct evidence they provide a significant bit of information but to draw any solid conclusions one still needs to identify the operative physical mechanisms involved. This approach to growth and feedback, along with other subjects, are further discussed elsewhere in these proceedings (Henshaw 85).

The diagrams of causation which are used to aid in finding autonomous system mechanisms (see figure 2.) are arranged to show autonomous processes as developing out of 1) numerous opportunities and 2) a single instigating impetus. Also depicted are 3) the subject behavior's resulting products, which may serve as opportunities for other things, 4) the impetus for other things that may result, and 5) the underlying motive (and demotive) processes which produce and then dismantle the system's internal process organization. These terms are not rigidly definined, except as referring to natural subjects which are hopefully identifiable but, of necessity, must remain substantially undefined.

The primary way these two research devices work is by directing attention to the natural subjects themselves and their inner creative workings, rather than by serving as representations of them. Combined with close observation, the result is a sophisticated ability to imagine how they work. The first step is to look for evidence of a succession of organizational growth phases and then for its active and passive functional parts.

SYSTEM CONNECTIONS: The boundaries between individuals are generally identified as resource/product pools through which the individuals materially interact while remaining oganizationally independent. These are also refered to as resource 'markets' or communication 'synapses'. They mediate and are the joints that physically connect process individuals, and are a primary source of process flexibility and resilience. Resource/product pools are also found to provide a timing buffer between parts of a system that operate at different rates and to provide dynamic continuity in processes that may incorporate long periods of a complete inactivity. They also create vast possibilities for process interconnection and growth.

The blood streams of animals offer an example of such common resource pools, as do economic markets and the atmosphere. Nerve synapses are examples of devoted market connections between autonomous nerve cell uptake and output locations. The circulation of the spinal fluid in which nerve synapses are located may or may not serve as a common resource pool for nerve communication.

This way of identifying bounderies and connections, somewhat confusingly, also allows for system individuals as a whole to interact with their own parts as separate individuals. In simpler views of system hierarchies this would constitute a strictly 'improper' relationship. A real world example, however, seems no harder to find than the process of scratching an itch. It can develop from a minor tickle into a whole autonomous process, stimulating and integrating the initially separate responses from one's body as a whole and it's itching parts.

UP AND DOWN CAUSATION: In general terms, opportunities for system development are seen as flowing from both the 'bottom' up and the 'top' down. Instigating impetus is seen, ideally, as flowing only from the 'bottom' up. Nutrition is a good example of top-down opportunity, for autonomous cell metabolism. Adiabatic cooling of a rising air mass creates opportunity for condensation in clouds. The flames of a fire spread new opportunities for combustion. Cell metabolism, vapor condensation and combustion, respectively, each provide good examples of bottom-up opportunity for the larger autonomous system developments of animal behavior, vapor drop conglomeration into rain drops and the many kinds of things that develop from a release of heat.

A particularly interesting example of top-down/bottom-up opportunity flow is provided by the role of a plant in providing fertile soil for future seeds. Though it may be streching the language a bit, it seems useful to look at this as an example of a higher order system providing a kind of material reverse image of the future for a lower order system to follow in its development. What is potentially provided is some kind of pattern memory of previous system creativity, a resource above and beyond the simple raw materials for subsequent original system development.

A pattern memory function is specifically evident, of course, in the role of a plant's seeds. It is also evident in such things as the roles of artifacts in nature and the economy in leaving around all manner of physical reflections and imprints of previous experience to directly or indirectly influence developments in the future.

Of some note is that if the flow of opportunity from higher levels to be made use of on lower levels were ignored, a variety of exclusive bottom-up, or 'reductionist', point of view would result (see Campbell 1974). A causal diagram might then still seem to be causally connected, but there would be no material 'images' of higher level processes in the physical context of lower order process beginnings. Nutrition would have to be a matter of random accident, and there would never be a cloud in the sky.

REFERENTIAL MODELING: The models used here are designed to be used to help in focusing one's attention on the natural subjects themselves rather than to represent them. For this reason they are termed 'referential' models. They are intended to be used as maps for exploring the territory of nature rather than as representations to be mentally substituted for nature.

Generally speaking all models can serve either as referential maps or representational substitutes for their subjects, simply according to whether one is looking with them, or just looking at them. Using models to see with, as windows on the world rather than as barriers to seeing the world, does not seem to require any special kind of symbolism, logic or language, only a change in the viewer's focus of attention.

A mathematical expression or natural 'law' that reliably predicts physical measures, for example, can either be seen as being the operative behavior itself or as being a reference guide for looking further within or beyond the behavior itself. There is often confusion about this because the common object of scientific research is to find mathematics that can serve as such a reliable substitute for its subject that we can no longer tell the difference. Normal perception also fabricates images that become indistinguishable from their subjects.

No matter how seemingly perfect, however, mathematical models are really just tools for human use in making numerical predictions. The 'laws of nature' are really just the rules we follow in applying those tools. They form a kind of map for us to follow, and are neither what nature actually does nor maps that nature follows.

Mathematical expressions are as different from how behaviors actually operate as temperature is different from molecular motion or as one's height is different from one's head. Formulas usually are not even built to imitate how the behaviors operate, but just to predict a measure of their consequences. Formulas are just abstracted relationships between measures. Real behaviors are not even composed of interactions between measures at all, but between things, through an unboundedly complex nested organization of physical object/process parts.

Measures and formulas are constructed for, or as if for, the purpose of avoiding the need to consider what is actually going on. This amounts to a design intent to be able to predict behaviors without needing to materially understand the behavior being predicted. In a successful formulation, any information that might expose the complexity of the real subject is methodically stripped from the record. Thus, simply trying to shift the perspective with which they're viewed, to successful formulations to see the subject with them rather than to look at them, can not be depended on for assisting in the development of material understanding.

What are more useful for developing a real understanding of things are measures and expressions that contain a depth of information about the subject, ones that can be used as 'remote listening devices'. Individual continuously recorded raw measures that monitor the subject from its initial growth through its final decay are especially useful for that purpose.

Though measure formulations of behaviors can lead to a misunderstanding of the subject, their practical usefulness hardly seems to have been exhausted, and their abandonment is in no way being suggested. What is being suggested is only that they be abandoned as accurate representations of behaviors.

3. TERMS OF THE MODEL

PARTS OF THE DIAGRAM: The terms used in this model of causation are intended to refer and direct the user's attention to concrete things, processes and situations and the autonomous process subjects through which they are related. In figure 2 and elsewhere, 'Resource Opportunity Pool' refers to whatever enables or is made use of in animating the growth and systemization of a subject process. 'Instigating Impetus' refers to whatever finally initiates the sequence of resource opportunities being made use of 'Product Opportunity Pool' and 'Resulting Impetus' are results of the process that become available for utilization by other autonomous processes. 'Motive' and 'Demotive' processes refer to sub-processes that serve to build up or break down the causal organization of the process.

In the model diagrams opportunity is indicated as a list of many items and impetus as a single item. A single impetus may not be identifiable in many circumstances, and coincidental multiple impetus is not ruled out. The importance of coincidental factors is considerably greater with respect to opportunity. Each circle symbol refers to the opportunity environment, or 'niche' of the subject process as a whole. An osciallation pulse is sketched inside the circle, referring to the autonomous process as a whole, when the subject's internal organization is being inquired about.

An autonomous system whole is refered to as a whole both in terms of its coherence of internalized relationships and in terms of its totality of developmental stages from initial growth to its final decay. Considering processes both as an 'organizational whole' and as a 'developmental whole' is crucial to competent thinking and research using this method. A system's organizational whole is simply one isolated moment or passing phase in its developmental whole. Another unique aspect of every autonomous system's developmental whole is that it happens only once. Incorporating things that seem to happen repetitively into the context of things that happen only once becomes a very revealing perspective.

As a graphic convention impetus is drawn connected to the subject process's niche with a solid line and opportunity with a dashed line. There is also a list called 'Other', not shown as directly connected with the subject process. 'Other' might include remotely related subjects such as the processes that created the subject's resource opportunities and general notes and descriptions.

At the bottom of the chart are columns for process notes. These are arranged to refer to the system's pre-development time period (origin), its developmental growth and climax (beginning), its developed operation (middle), its degenerative collapse and decay (ending), and its remnants (legacy). Together these terms are intended to refer to all the concrete interconnections between the subject and other things and to begin a process of organizing information about the internal workings of the subject.

FIRST STEPS: The key idea in describing opportunity is contained in the phrase "made use of in animating the growth and systemization of the subject". Eating a prepared meal with friends makes use of a numerous kinds of opportunities and offers a good example of a systematic process displaying autonomous development. It begins with little plan or program other than opportunity and normally develops a coherent animated behavior of its own.

Once the right opportunity has accumulated some final impetus occurs that signals everyone to begin. That impetus might be the saying of a prayer, the unfolding of a napkin, simply a poignant pause in the conversation or minor gesture. The specific character of that impetus may or may not significantly influence the process of the meal as it develops. The opportunities made use of in the development of the meal would generally include appetizing food, utensiles, hungry people, a certain amount of privacy and having interesting things to talk about between bites.

Upon the impetus to start, the systemization of each individual's eating process begins, perhaps with the arranging of utensils, tasting the beverages and appetizers, adjusting the seasonings, and exploring the assortment of foods on one's plate for the first thing to eat. Both the things and the acts in which they are employed are 'made use of' in the developing systemization of the whole. As the meal develops each individual's eating, thinking and conversation develops in relation to the that of the others. That integration into an autonomous whole often becomes the basis for an especially intimate kind of group and personal experience.

Of first interest in this kind of study is an accounting of the basic opportunities, the impetus that instigates active process development and the diverse leading steps of development. Those developmental steps generally occur before there is an established system to cause them, and usually lead to the development of the system in a remarkably direct way. Each step seems to just smoothly fall into place, producing taylored opportunities for the next almost as if directed toward the eventual end.

Understanding the premature coherence of system developmental processes is the most difficult part of investigating autonomous systems. The leading steps of a systemization are always impressively intricate, seemingly spontaneous, and evidently quite necessary to the development of the system's climax organization. In any particular case the leading steps are, indeed, the particular discovery steps by means of which the system develops.

Leading steps such as these can be observed in the development of virtually any identifiable process. They are normally observable both as a diverse series of individual events and in growth trends in measures of of the process. If not in other measures as well, growth trends are generally evident in the rates of succession of leading events and in their rates of material and energy flows.

In the development of eating a meal, for example, growth trends might be found in the sound of utensil use, the frequency of hand motions or, complexly, in the ebb and flow of conversation, as well as in the rates of food consumption. Clearly, none of those measures or any mathematical relationship between them actually are or even adequately describe the subject system and its development. They might, however, serve as good 'listening devices' and indicate where various phases in the development of system coherence begin and end. This is the manner in which measures, measure functions and the term 'growth' are used in this method of investigating causation.

DIRECTED CAUSATION: There seem to be two technically correct and useful ways to use the terms 'directed opportunity' and 'directed impetus', and both are a little complicated. Neither is the sense of 'directed' for meaning opportunity or impetus intended for a certain effect, though that may be a temptation. That implies preconception on the part of the subject system or something in its context. One might use that sense in discussing engineered systems or human volition, where human control of systems rather than their autonomy is the subject, but not in discussions about autonomous systems themselves. It would deny their autonomy.

The main system feature that 'directed' opportunity and impetus are used to refer to is the linking of separate events into system networks. 'Directed' impetus, for example, can be used to refer to a spark that instigates a chain of events resulting in opportunities from which a spark can develop, i.e. impetus that produces opportunity feedback for itself. This describes a multi-level causal chain involving both impetus and opportunity links as might be found in an internal combustion engine. The term could also be used to refer to impetus that instigates a direct succession of impetus creations as a process in itself, as in a nuclear chain reaction where the important product of a fision is the impetus for others rather than the context of opportunity for others.

'Directed' opportunity, similarly, can refer to a fuel mixture that enables the creation of the impetus for producing a similar fuel mixture, like the fuel mixture in a cylinder that results in the creation of a relative vacuum into which a later fuel mixture rushes. The term can also refer to things like surfaces exposed to weathering that upon the appropriate impetus expose more surfaces to available weathering impetus, creating a succession of opportunity as a process in itself.

With these terms autonomous organization can be described as directed successions of either impetus (enabled by available opportunity) or opportunity (instigated by available impetus) or of alternating impetus and opportunity that instigate and enable the development of each other. The systemization of a process from unsystematic origins is the development of one or a combination of these kinds of directed opportunity and impetus which can then be interpreted as the system's organizational structure.

A second general way in which 'directed' opportunity and impetus might be used is for referring to the degree and kind of specificity that opportunity and impetus have toward each other and their results. Some things, like supercooled water, can present highly specific opportunities for almost completely unspecified impetus. Supercooled water can begin to crystalize following almost any kind of minor disturbance. The crystalization could follow many different paths through the fluid but will result in much the same outcome no matter which path is taken. Thus, there is really only one opportunity for results available, and almost any impetus will bring it about. The opportunity of the situation is 'directed' toward a specific end.

Other things, like the fracturing of a diamond, require a very highly, but not absolutely, specific impetus, and the end result may be uniquely determined by the path along which the propagation of the fracture begins. This kind of specific opportunity could be called 'structured' opportunity. Still other things, like the crystalization of snowflakes, appear to arise out of both unspecific impetus and very complexly structured opportunity. There is a tremendous, but discrete, variety of significantly different snow flake patterns that can follow from virtually identical originating conditions.

This second sense of 'directed' as 'specific' opportunity and impetus may offer avenues to understanding individual differences between systems of similar origin and for developing abilities to specifically predict and influence autonomous behaviors. Which sense of the term one chooses to use seems to turn on whether one is taking a forward perspective in time and talking about individual factors (the first use) or whether one is taking a backward perspective in time and talking about a situation as a whole (the second use). The first is primarily used here because the discussion concerns the evolution of the system structures that can then be viewed in terms of the second.

OPPORTUNITY AND IMPETUS: The detailed uses of the terms 'opportunity' and 'impetus' have been left a little vague so far, and perhaps should remain at least somewhat flexible. Ideally impetus would refer to something that sets the use of otherwise passive opportunities in motion, a kind of final outside cause, beyond which internal causation takes over.

Various problems arise with that in experience. One is that determining a particular impetus is sometimes a little like 'finding a needle in the haystack'. As with finding the final cause of a process of spontaneous combustion in an actual stack of hay, one with too high a moisture content, the search can be quite hopeless. In trying to identify which unkind phrase started the process of an uncontrollable argument there's a little more to go on, but still enormous difficulties. Generally, instigating impetus is some very minor and unmemorable occurrence in the midst of a great many others. There are some helpful techniques though, like looking closely at a continuous measure of the process and considering the impact of events that coincide with the inception of its growth.

That they can be exceptionally hard to find does not, however, necessarily mean that autonomous processes can develop without any instrumental impetus. Why, and whether, the development of processes requires some specific initiating event is a very difficult issue. The general evidence for it, though, is strongly affirmative. Procreative conception and seed germination are preconditions for the development of living organisms, snow flakes can't develop without a center of crystalization and someone has to break the silence for a conversation to begin.

Because of these difficulties, in order to maintain 'impetus' as a meaningful term, it must be broadened to include 'relatively' final outside causes. How wide a range of things that might be used to refer to depends on the purposes of inquiring into any particular subject and the skills of the observer.

In general it seems useful to let the meaning of impetus be broad enough to include 'precipitating opportunity'. This creates an option to talk about impetus in a way seemingly incompatible with the idea as first presented, as 'irresistible opportunity' rather than as the initiating outside act of taking it. The stage performer in bringing a performance to an end precipitates applause, providing the impetus with a carefully played moment of silence. A toy or piece of equipment that breaks down may precipitate its repair or replacement or perhaps the development of interests in something entirely different. In those two cases precipitating opportunity is created by the breaking off of a process and an unusual period of inaction.

A more important kind of precipitating opportunity is exemplified by the closing of a switch that might as well be considered as the impetus for the development of a current. In reality it creates opportunity for the development of an autonomous electro/molecular current surge process, following some bottom-up impetus on a scale that is probably beyond the limit of measure. Delicate measurements will show the current to actually grow, at rates quite different from the closing contact of the switch, and may even show some of a current growth's developmental complexity.

The opportunity presented by the closing switch is an effective 'command' opportunity, creating a situation of developmental instability for other things. Much the same is true of a friendly smile 'triggering' a friendly smile or an offering of money that precipitates competition or the coincidence of appropriate amounts of water, darkness and warmth that germinate a seed. In general, there are a lot of complex happenings that occur seemingly as if by just pressing the right button. Lower level system behaviors seem more dominantly composed of such readily predictable 'command' opportunity junctions, and so seem mechanistic. Higher level systems seem to develop by the evolution of more and more reliably predictable ones.

As a process becomes systematized, the role of outside impetus tends to vanish and be replaced by impetus and precipitating opportunity generated from within. This transition from outwardly originated causes to inwardly generated causes is the transition of a system to becoming causally autonomous.

MOTIVE PROCESSES: Motive processes are those that produce the internalization of causes within a developing autonomous system. If that internalization of causes proceeds systematically, it can often be identified and described as an independent sub-process in its own right. With sufficient evidence it is called the system's 'motive process' for being its 'system making' and 'opportunity directing' sub-system. It's what builds the means by which a system operates and its source of developmental animation.

One research technique that helps identify a system's motive process(s) is to study the underlying rates of change of a system's development, as found by taking the derivatives of its growth curves (figure 3.). If the original curve of the measure is used to direct attention to the system, then the measure's first derivative can be used to direct attention to the system's primary motive process.

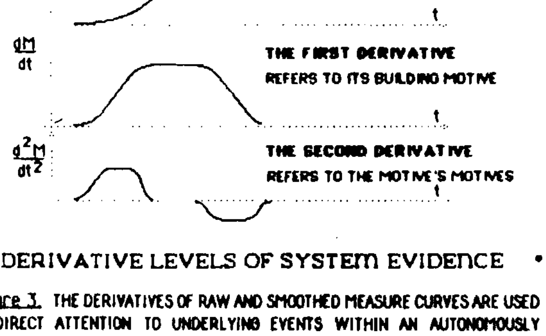
The key idea here is that if the system is one that achieves a stable climax (as shown) then its motive process is one that goes to completion as the system achieves its climax. The motive process is the system building process, and the building process ends as the construction of the system is finished. When the system eventually begins to disorganize (to organizationally collapse and then decay) the first derivative of its measures would direct attention to a separate motive process for the system's disorganization, its demotive process.

This same procedure can be used as a continuing regression for inquiring into still further underlying motive processes (using 2nd and 3rd derivatives, etc.). It might also be used inversely (looking at 1st and 2nd integrals, etc.) for directing attention toward the systems that the subject process might be the underlying motive process for.

It is important to note that derivative and integral curves do not reliably identify the underlying and overlying motive and motivated processes, but are just a helpful tool for use in finding them. In some cases concrete motive processes are quite firmly identifiable, usually identified from having explored diverse evidence of what builds the system's causal process.

One of the best examples is found in economics, where business investment is pretty clearly the instrumental work of building the system's operative process. The investment process offers successively more potent directed opportunities for developing, absorbing and interconnecting the interests and activities of individuals in the economic system.

It is fairly easy to generalize the term 'investment' to say that it is 'the motive process' of economies, i.e. that it is investment in the broadest sense that builds the system and animates its autonomous development. In general, identifying something like investment in a subject system is necessary to satisfactorally determine that what is being studied really is a concrete autonomous system. Without



• DERIVATIVE LEVELS OF SYSTEM EVIDENCE •

Figure 3. THE DERIVATIVES OF RAW AND SMOOTHED MEASURE CURVES ARE USED TO DIRECT ATTENTION TO UNDERLYING EVENTS WITHIN AN AUTONOMOUSLY DEVELOPING WHOLE. IN PLACE OF USING SOPHISTICATED COMPUTER PROGRAMMING IT IS NEARLY AS USEFUL TO MANUALLY OR VISUALLY DRAW THE PRINCIPLE TREND OF A MEASURE, LOCATE ITS INFLECTION POINTS AND MENTALLY DIFFERENTIATE OR INTEGRATE IT.

identifying a functioning pair of system and system making processes, the study of an autonomous system may be just as likely to identify only some personally symbolic images as to produce an understanding of a concrete autonomous individual.

4 A MODEL APPLICATION

The use of this study method often runs into various difficulties, and often takes surprising directions. It's progress usually follows the kind of meandering accumulation of ideas which then occasionally brings about a running flow of insights like any true discovery process. The following roughly describes an investigation that was being done as its description was being written. As such this is roughly a diary of how an experimental application of the method took place. It will display strengths as well as the weaknesses in the method and in its still relatively inexperienced application. What ties it together is attentive direct observation of the subject of study, its growth trends and the chains of events that they direct attention to.

The subject that turned up to talk about is that of a running dribble of water, as commonly seen on a window pane or car windshield after a rain, as well as on many other surfaces that have recently been splashed with water. An individual water dribble as a whole event in time begins with a stationary or gradually sliding drop that then develops a quick and sometimes erratic running motion for a short distance and then stops again.

This example was chosen for various reasons, for leading toward insights into the subject of flows in general, for the ease with which it can be directly observed and experimented with by others and for how it exposes the real intricacy of eminently simple and common events. It was also chosen to help show how the study of uncontrolled individual natural occurrences, even without an impressive amount of scientific hardware, can be made the subject of a careful natural science research.

The study was done without the advantage of mechanically recorded direct measures, other than a few still photographs. Detailed slow motion video recordings would have been a great benefit as would computerized comparisons with mathematical physics models. It is surprising, however, just how much can be picked up by eye.

The first step is to closely observe the subject, collecting impressions that may later fall together as part of an ability to imagine the subject's intricate actual workings. Of special significance are developmental changes in the subject that might direct one's attention to the growth of specific new systems of behavior and making a general survey and description of the context in which those developmental changes occur. These beginning steps are effectively the work of filling in some of the lists in a causal diagram such as that shown in figure 2. The general contextual observations and description would go into the list called 'other'.

Given a chance, drops of water run downhill, and if traveling on a tilted surface they often follow an irregularly meandering path, often changing their speed and direction for no apparent cause. The path and speed of water drops on a surface is strongly effected by their merging with other drops that may be in the path and by the texture of the surface. Close observation of moving water drops is somewhat difficult and is aided by both bright light and a dark background surface to produce visual contrast. In experimenting with different amounts of water at various tilts on various kinds of surfaces the general patterns of behavior begin to become apparent and some particular examples found that seem to exemplify them.

Figure 4. is a sketch of the results of a single dribble of water. The two kinds of trails suggest that the drip had two systems of travel, and that there were transitions between them. The drip's travel changed from that of a gradually sliding drop to a quick running dribble and then suddenly slowed down again. The particular dribble that produced this pattern of evidence developed from a drop of water that had been placed on the smooth, dry and oil cured bottom of a tilted cast iron pan. In initial slow movement period it left a broad sheet of water behind, then as it began to move rapidly it left a narrower and fuller trail of water and then returned to moving slowly and leaving a wider trail as before.

More 'ideal' surfaces such as well cleaned new glass were tried, but then no changes in drip behavioral states were observed at all, only steadily traveling drips leaving smooth trails of water behind that tapered gradually as the drip got smaller and smaller. Water drips on smoothly oiled new glass and on clean glazed ceramic surfaces with microscopic scratches both demonstrated interesting but less dramatic change of state behaviors than the surface of the iron pan. These observations suggest that complex surface textures are part of the opportunity needed for developing the distinct changes of state which were observed. Surface variations clearly effect water drop flow states, but it is equally clear that the development of those states of flow involves the entire drop and its internal and external interrelationships.

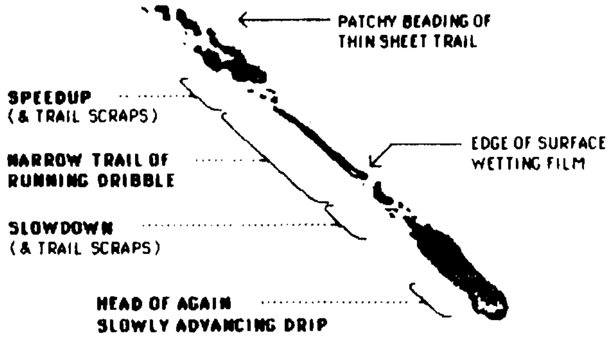
The example (figure 4.) that was chosen to exemplify the change of state being studied shows what might be detailed artifacts of system changes. Between the times when the drip was leaving behind a thin sheet of water (that beaded up in irregular patches) and leaving a continuous narrow trail of water behind (that beaded up in lines), it left tiny scattered scraps of water. These might indicate transitional states of some kind occurring after the previous pattern of trail deposition had been disrupted and before the new pattern had become established.

Further experiment, however, showed that these transient states in trail deposition were not reliably reproducible. They might be evidence of an interplay of dynamic systems, as they first appear. They might also be only an indication of the particular conditions of the surface over which the drip traveled, or something else. An insufficiently complete record of the event process was made to be able to make that determination.

If taken as physical evidence of an interplay of internal systems the 'speed-up scraps' might indicate that as the drip suddenly accelerated on its rapid run it might have first left an especially thin sheet of water behind (before establishing its narrow one) which beaded up in significantly smaller than normal patches. The 'slow-down scraps' might indicate that as the drip suddenly slowed, its fuller and narrower tail was able to drain to the head of the drip more completely, leaving water behind only at particularly 'sticky' points on the surface.

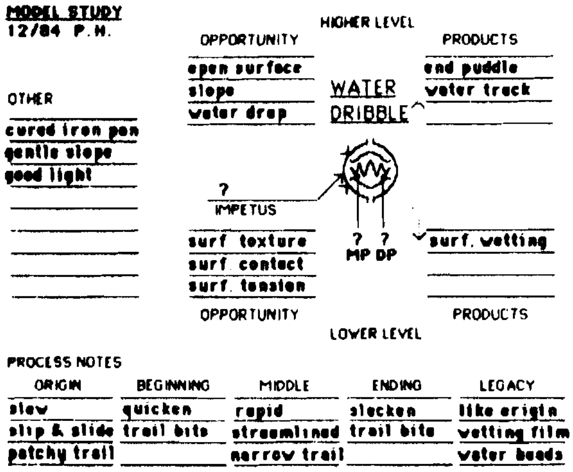
Interesting, but uncharacteristic, examples of system behavior such as this one are often ruled out of the evidence in other kinds of scientific research. Here they are recognized as being 'exceptions that elaborate the rule' and are found to be very valuable as such for suggesting new ways to inquire into both individual and normal cases.

What this special example provides is some direct suggestion of transitional processes, that go to completion within the beginning and ending periods of the subject system as a whole. These serve as the first direct leads to the identification of the whole system's motive



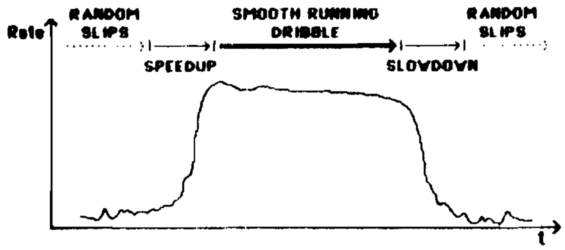
• THE REMAINS OF A WATER DRIBBLE •

Figure 4. THE WATER TRAIL OF A DRIBBLE LEAVES A HISTORY OF THE PROCESSES BY WHICH IT TRAVELED. THE ABOVE WAS QUICKLY SKETCHED AFTER OBSERVING A SINGLE DRIBBLE THAT LEFT A RECORD OF SYSTEM DEVELOPMENTAL CHANGE INVOLVING TWO DISTINCT SYSTEM BEHAVIORAL PERIODS



• BEGINNING DIAGRAM OF CAUSAL SYSTEM •

Figure 5. THE BASE DIAGRAM IS USED AS A NOTE PAD FOR KEY OBSERVATIONS. ONCE THE GENERAL OBSERVATIONS ARE COLLECTED ATTENTION TURNS TO TRYING TO DISCOVER THE SYSTEM'S MOTIVE AND DEMOTIVE PROCESSES.



• CONCEPTUAL DRIBBLE FLOW RATE •

Figure 6. THE OBSERVATION OF SYSTEMATIC BUILDUP AND DECLINE IN THE RATE OF THE DRIP'S MOVEMENT SUGGESTS EXACTLY WHEN AND AT WHAT RATES A SYSTEM'S MOTIVE AND DEMOTIVE PROCESSES OCCURRED. THE ABOVE CURVE WAS DRAWN TO SHOW RATES OF DEVELOPMENTAL CHANGE THAT ROUGHLY CORRESPOND TO THE ACCELERATIONS DIRECTLY OBSERVED IN WATER DRIBBLE EVENT PROCESSES.

and demotive processes. These little scraps of evidence also contribute to a suggestion that the dribble could be a coordinated system of interaction between processes occurring at its leading and trailing parts since they change together.

A further useful observation is that there is also a second kind of water trail that is sometimes left behind, a thin film remaining where the tail of the drip has beaded up. It evaporates quickly but when left in the track it is clearly visible as a vanishing surface discoloration. The fact that it is not always apparent indicates that there are at least two kinds of surface wetting, one that makes a bond stronger than the internal cohesion of the water (leaving the surface contact film behind as the tail beads up) and one that makes a weaker bond (separating from the surface as the tail beads up).

The direction in which the beading of the tail occurs is also useful evidence. In some cases the tail pulls away from the surface in the direction of the drip's motion and sometimes perpendicular to it. In the latter case the trail beads up generally toward the center. Within the portion of the tail still connected to the head of the drip tiny rivulets of water trickle down toward the head with the edges beading up on either side.

When the tail is very short and the water's surface tension pulling the trailing edge downhill in the direction of drip's travel, it looks like its surface adhesion is holding back the drip's advance. Sudden individual releases of surface adhesion at the rear sometimes do visibly correspond to forward movements at the head.

In any case the water beading and trickles at the rear are always left behind whenever the drip head accelerates. This evidence of separately autonomous behaviors occurring at the head and tail of the drip helps to direct the search for the change of state process displayed by the dribble as a whole toward events at its leading edge.

From this survey of surrounding evidence a basic causal relationships diagram can be produced (figure 5.) The resource opportunities for the development of a dribble include the drop of water, its surface tension and surface wetting characteristics and the slope and texture of the surface on which it flows. The product opportunities include a trail of water that beads up by other processes and finally the puddle or second slow drip that is left at the end. These are listed in groups more closely associated with relatively higher or lower level systems.

The next level of detail in the investigation begins the way the general investigation did, with looking for evidence of developmental change. The basic evidence, of course, is the change in the drip's rate of travel as approximated in figure 6. The focus of interest is on the growth periods when increases in the rate of flow are followed by still greater increases.

Before its acceleration the drip gradually creeps forward or makes sudden forward slips, extending the lead edge of its surface contact by small crescent shaped fingers. Sometimes those surface contact slips extend the lead edge of the drip by relatively large steps and sometimes by very tiny steps. Their motion is if jumping from line to line. Sometimes they come in no relationship to each other and sometimes in little flurries, moving the drip forward in a somewhat regular surface nibbling fashion. Sometimes they occur on alternating sides of the line of drip travel and sometimes on only one side, redirecting the line of drip travel.

The slow drip is relatively flat and limp, and as a slip extends its surface contact the drip head flattens further in response, and only then slumps forward filling out the new surface contact area. This shows, first, that the drip moves forward as a result of extending its leading edge of surface contact, second, that there is a kind of molecular propagation of surface contact that can proceed rapidly enough to precede the motion of the drip rather than follow from it.

From these observations it is possible to resolve the system of the slow movement period of the drip into the workings of two separate autonomous systems. The molecular propagation of surface contact and the forward sliding of the drip head behind it. The two follow more or less sequentially but they are not tightly integrated into operating as a single system. Each is necessary to the other, and creates opportunities for the other but each proceeds independently of the other.

What follows is a quickening succession of events. The slips of surface contact seem to become smaller, more frequent, more centered and more fluid. Each apparently leads more directly to the next until a smooth and rapidly running progression of surface contact extension develops. The drip head changes shape dramatically, swelling from a sagging passive bulge into a tight round bulb, accelerating down a straight, narrow and rapidly advancing track of surface contact beneath it.

These parts of the head of a drip in its two states of movement are shown in figure 7. A running drip's narrow track of surface contact can be experimentally observed by looking down through the head of the drip to see where it contacts the surface, as shown in the sketch. What a quick glimpse appears to show is a dark central stripe of fully wetted surface contact beneath the drip, with a band of non-wetting surface contact around it. In some cases it appears that a second level system change occurs, with the running drip losing all wetting contact with the surface and leaves no trail behind at all. In that third level system the drip might actually roll, rather than slide, down the surface.

In the formation of the second level system the initially independent parts of the slow drip's motion are becoming thoroughally transformed and integrated to form a tightly unified new whole system of action. The disconnected surface slips are changed into a smooth propagation of a surface contact track. The forward slumping of the drip head becomes the quick downhill glide of a nearly spherical object.

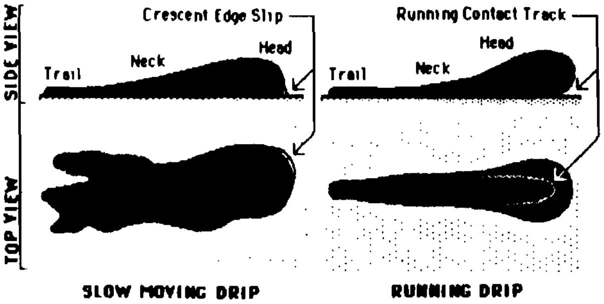
The next step is to try to identify what produces this transformation, the motive process that directs the opportunities produced by the separate parts toward each other's transformation and integration into the new whole. In this case clearly identifying and describing it would require information beyond the present limits of observation and so can not be done in a fully satisfactory way. Some tell-tale information is available to help produce a moderately well informed speculation.

The beginning of a dribble's systemization seems to be the first time the forward slumping of the slow drip triggers a second significant surface slip. That initial triggering response would appear to be its 'running start' and impetus. Nothing comes of it unless the local surface texture of the pan, in this case, provides sufficient contact extension opportunities for a new system to develop.

The initial limp response of the drip head to extensions of surface contact seems to serve as a buffer, absorbing and restraining the forward action of the surface slips. Then there is a quickening and then merging sequence of surface slips. In the observable first steps their dynamic appears to be more and more directly conveyed to one another. That might occur if the ripple that each slip sends through the swelling drip head is more and more efficiently conveyed, and perhaps directionally focused, to instigate surface contact advance elsewhere.

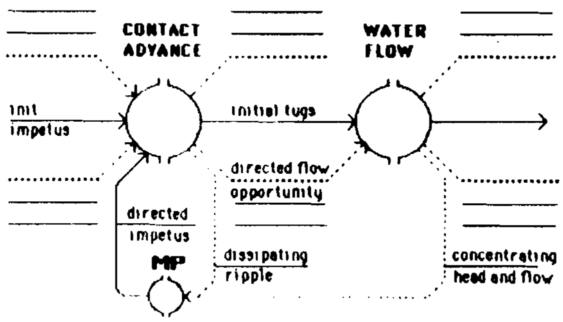
This scenario is sketched as a tentative motive process diagram in figure 8. The motive process is shown as a special process that makes use of selected opportunities produced by the two separate processes of the slow drip's motion. Its product is an impetus for subsequent surface contact advance. It is called 'directed impetus' for its tendency to initiate particular surface contact advances that produce opportunities for the motive process and thus for the systemization of the process as a unified whole.

As that systemization runs it course and the dribble approaches its climax shape and behavior the head of the drip leans further and further in front of its leading line of surface contact. At climax the leading face of the drip seems completely folded over on top of its leading line of surface contact and to extend contact by laying down on top of the pan's surface rather than by sliding or extending surface



• CONTACT EDGE AND DRIP SHAPE COMPARISON •

Figure 7. THE SLOW DRIP MOVES FORWARD BY PROJECTING LARGE AND SMALL CRESCENT SHAPED SURFACE CONTACT SLIPS THAT BECOME CHANGED INTO A RAPIDLY ADVANCING TRACK OF SURFACE CONTACT CENTERED UNDER THE RUNNING DRIP. IN PRACTICE THE RUNNING DRIP'S CENTER TRACK IS OBSERVABLE ONLY BY LOOKING DOWN THROUGH THE TOP OF THE DRIP TO SEE A DARK STRIP CORRESPONDING TO THE AREA OF SURFACE WETTING BELOW.



• BEGINNING MOTIVE PROCESS DIAGRAM •

Figure 8. THE SKETCH SHOWS THE POSTULATED MOTIVE PROCESS THAT DIRECTS THE OPPORTUNITIES OF THE INITIALLY SEPARATE PARTS TOWARD THEIR TRANSFORMATION AND INTEGRATION IN THE NEW SYSTEM WHOLE OF THE RUNNING DRIBBLE. MORE WOULD NEED TO BE KNOWN ABOUT HOW THE DRIP'S SURFACE CONTACT EDGE PROPAGATES TO DEVELOP THE HYPOTHESIS MUCH FURTHER.

slips. This suggests that there may be other developmental phases of the motive process that the diagram offers no suggestion about. One normally looks for a motive process that comes to an end only with the the final establishment of the the subject system's climax organization. What has been discussed so far seems only to have been the growth phase of the motive process, and its climax, collapse and decay remain to be considered.

The identification of the motive process remains speculative and a little vague. It is also reasonably well informed in many ways. In any case, it pushes the limit of what can be observed and identifies a plausible process that contributes to and would come to an end with the establishment of the dribble's climax system of running travel.

As soon as the running drip loses its necessary mass or runs onto a surface that is unconducive to its system of extending surface contact, it stalls. The demotive process is not abrupt, but as if stumbling and breaking the system's stride, perhaps disorienting and dissipating the once tightly directed opportunities that it had operated with. The trail beads up and what is still connected to the head drains into it. The head flattens out and the cycle may repeat, until the drip runs out of water or sloped surface to travel on.

One would hardly say that this answers all the interesting questions raised, but it has at least helped to focus some of them, and has left a clear record of conclusions that could be revised based on new and better evidence. The fact that a specific motive process for the development of the system could be at least partially identified, making it possible to identify autonomous organization on more than one level, suggests that the study would serve as a useful starting point for others.

Critical readers will note that the above is arranged much as if a study of an single natural event, informed by the close observation of a great many similar events. As such it develops a somewhat 'improved' image of that single event, an idealization of it. What that image legitimately is is a kind of map, generated from the event, for use in aiding the exploration of other events. What it is actually a map of, since its specific subject no longer exists, depends entirely on what kinds of explorations it is found to be useful for.

5. CONCLUSION

The foregoing presented a general technique for investigating causation in autonomous systems. It has been in use and development for about eight years and has achieved a certain level of formal organization. It is hoped that it can be made direct use of in the serious professional study of autonomous systems of all kinds. In particular it is hoped is that it will contribute to helping people identify and distinguish between the internal and external causes of the events occurring around us. In the process of being applied to these and other uses it would be expected to significantly change and develop.

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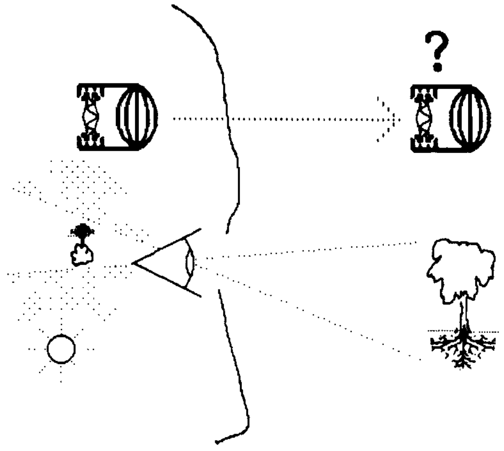
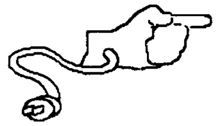


- SUBJECT
- IMAGE
- APPETITE FOR KNOWLEDGE
- VIRTUAL STRUCTURE
- PROJECTION OF CAUSES
  (HOW WE UNDERSTAND)
- PROPOGATION OF CAUSES
  (HOW WHAT WE UNDERSTAND WORKS)

WHAT MAKES NATURE WORK ?

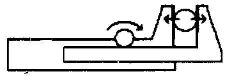
ANIMATED GLOVE ?



CONSTRAINTS ?

CONTROL IMPOSED FROM A SYSTEM'S BOUNDARY ?

CONTROLED LIKE MEASURES ?



APART FROM CONSTRAINTS, BEHAVIOR IS INCHOHERENT THE SAME WAY UNCONSTRAINED MEASURES ARE ?

ANIMATED HAND ?

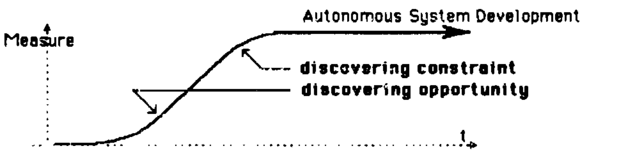
OPPORTUNITIES ?

ACTIVITY STEMS FROM USE OF CONTEXTUAL OPPORTUNITY ?

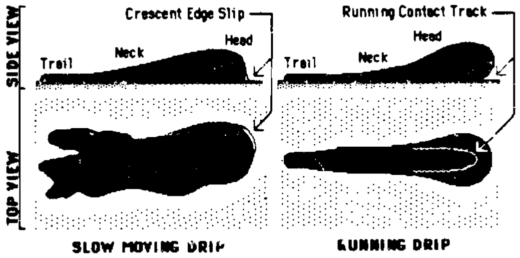
INDEPENDENTLY ASSERTIVE ?

NATURAL BEHAVIOR IS COHERENTLY IMPULSIVE, MAKING USE OF DISCOVERED OPPORTUNITY THE SAME WAY FLAME AND HUNGER DO ?

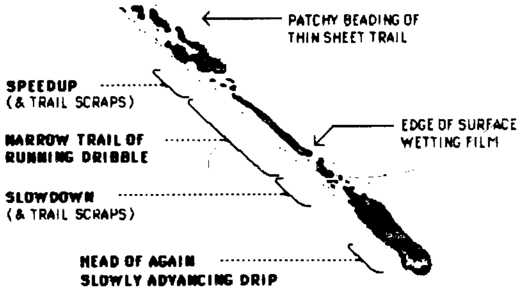
OR BOTH ?



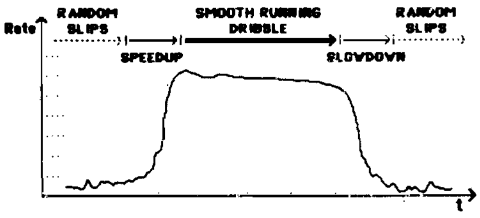
(What makes independent, but matched, opportunity and constraint ?)



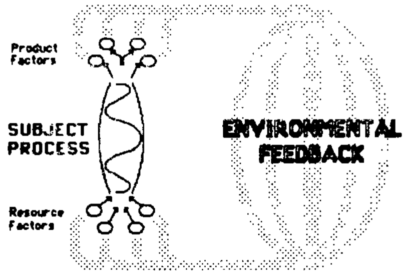
• CONTACT EDGE AND DRIP SHAPE COMPARISON •



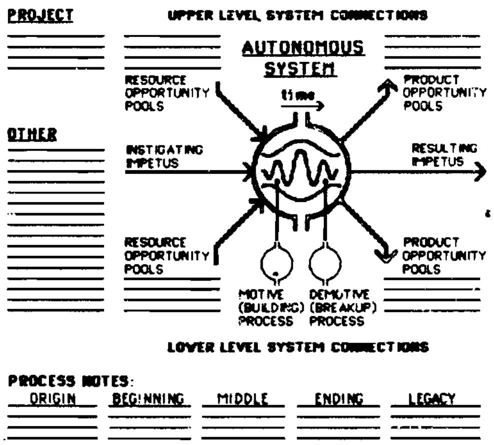
• THE REMAINS OF A WATER DRIBBLE •



• CONCEPTUAL DRIBBLE FLOW RATE •

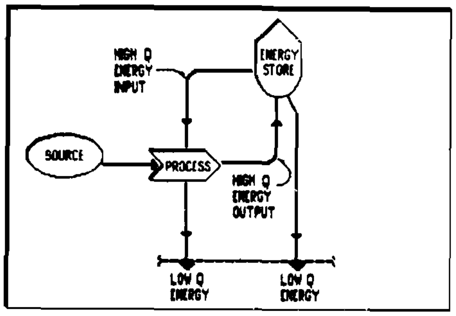


• A GENERIC PICTURE OF PROCESS FEEDBACK •



• BASIC MAP OF AUTONOMOUS CAUSATION •

TWO GENERAL SYSTEM MODELS OF ECONOMIC PROCESS

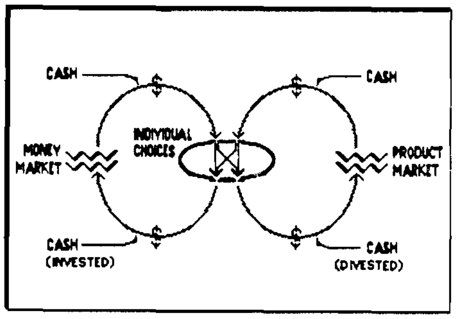


1 ENERGY BASED

COLLECTION,
TRANSFORMATION,
DISPERSAL,
TRADE

DESIGNED BY:
HOWARD T. ODUM

SEE:
SYSTEMS ECOLOGY, 1983



2 MONEY BASED

EXCHANGE &
CONCENTRATION,
DIVESTMENT
INVESTMENT

DESIGNED BY:
PHILIP F. HENSHAW

SEE:
"UNCONDITIONAL POSITIVE FEEDBACK.."
SGSR PROCEEDINGS, 1985

ODUM ENERGY MODEL

BASIS: HIGH QUALITY FORMS OF ENERGY ARE EMPLOYED IN CONVERTING NATURAL RESOURCES INTO OTHER HIGH QUALITY FORMS OF ENERGY WITH A BY-PRODUCT OF VERY LOW QUALITY FORMS OF ENERGY WASTE

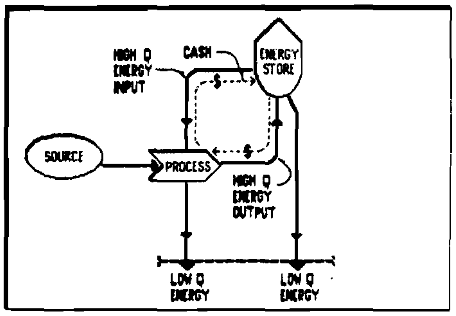
USE: ENERGY SYSTEM THEORMS AND SCHEMATIC MODELING FOR SYSTEM TRANSFORMATIONAL PROCESSES

HENSHAW MONEY MODEL

BASIS: MONEY CIRCULATES BY BEING TRANSFERED FROM THE OWNERSHIP OF ONE PERSON TO ANOTHER, EITHER THROUGH THE PURCHASE OF COMMODITIES OR IN EXCHANGE FOR COMMITMENTS FOR A RETURN

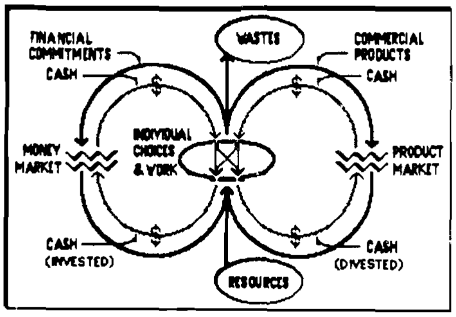
USE: ECONOMIC THEORMS AND SCHEMATIC MODELING OF ECONOMIC PROCESSES

TWO GENERAL SYSTEM MODELS OF ECONOMIC PROCESS



3 ENERGY BASED

ADD:
COUNTERFLOW
MONEY CIRCULATION



4 MONEY BASED

ADD:
COUNTERFLOW
PRODUCT AND FINANCE
CIRCULATION, THEIR
RESOURCES & WASTES

ODUM ENERGY MODEL

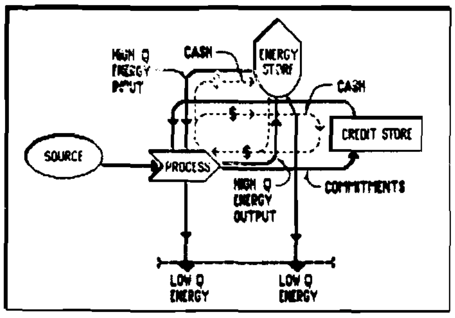
BASIS: MONEY FLOWS IN THE OPPOSITE DIRECTION OF THE CREATION OF ENERGY QUALITY AS A REWARD FOR ENERGY VALUE ADDED

HENSHAW MONEY MODEL

BASIS: THE MATERIALS EXCHANGED ARE GOODS AND SERVICES IN THE PRODUCT MARKET AND VARIOUS KINDS OF COMMITMENTS FOR INVESTMENT RETURNS IN THE MONEY MARKET

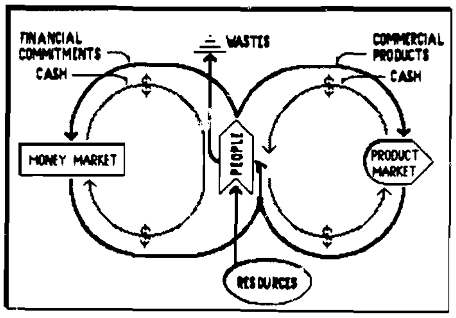
NOTE: ORIGINAL RESOURCES AND FINAL WASTES HAVE NO MONETARY VALUE BECAUSE OWNERSHIP IS NOT EXCHANGED IN THEIR USE OR DISPOSAL

TWO GENERAL SYSTEM MODELS OF ECONOMIC PROCESS



5 ENERGY BASED

ADD:
CREDIT STORE LOOP
CASH FOR COMMITMENTS



6 MONEY BASED

REPLACE
MONEY WITH ENERGY
MODEL SYMBOLS

ODUM ENERGY MODEL ⟺ **HENSHAW MONEY MODEL**

ODUM ENERGY MODEL	IF	HENSHAW MONEY MODEL
PROCESS	⟷	PEOPLE
ENERGY STORE	⟷	PRODUCT MARKET
CREDIT STORE	⟷	MONEY MARKET