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THE PLACE OF GENERAL SYSTEM THEORY
IN BIOLOGICAL PROBLEMS

By
Edward J. Tyczynski

A Thesis submitted to the University of Durham,
for the degree of Master of Science.

University of Durham.

November, 1970.



I dedicate this, my first text, to my wonderful
wife.

E.J.T.

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ABSTRACT

Bertalanffy's "General System Theory" is a recent attempt to produce a theory which has relevance to the totality of human knowledge.

The lack of success in such an endeavour is due to the paradox encountered therein. An analogous paradox is encountered when viewing the photograph on page A. As one views the photograph, two forms express themselves, (a) 'faces' are realised at the expense of the vase, (b) the 'vase' is realised at the expense of the 'faces'. Such 'faces'/'vase' situations (opposing systems, opposing logics) are encountered within all basic concepts.

This paradox is investigated by study of more general literature relating to time, probability and information and by way of symbolic logic with its process of conceptual transformation from induction to deduction.

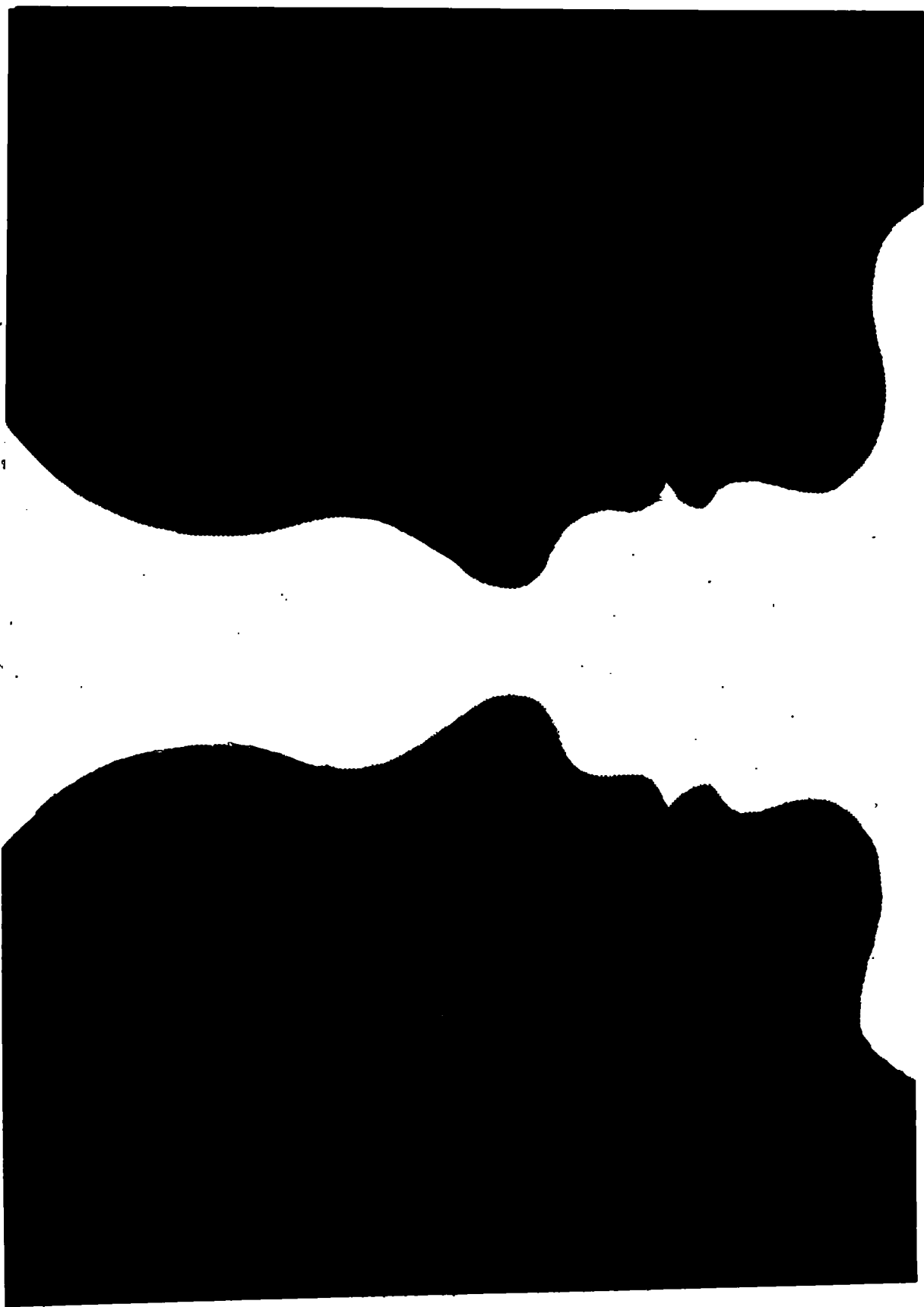
The results of some experiments on the phenomena of form are presented and are applied to biology through a consideration of the concept of evolution.

It is concluded that evolution is a composite of two parts:-

PAGE A

Faces-Vase Optical Illusions.

A



(1) An increase in the diversity of the phenotypic screens adapting to the environment, (that is evolution in the Darwinian sense).

and (2) Increase of the living state on earth. The 'struggle' is for maximum 'potential' of life, maximum flow of energy through the evolving system, the biosphere.

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INTRODUCTION

Biology is the science which deals with the origin(s), physical characteristics, etc., of plants and animals. Defined in this way the science is immediately seen as a collage of sub-sciences. Over the past 150 years the main development in biology has been the fragmentation of the science itself into many sub-units, botany, zoology, ecology, taxonomy, cytology, etc. Each sub-discipline has developed its own impetus and even a cursory look at the enormous literature shows that the main advances in knowledge have come within the sub-disciplines. One main effect of this has been to produce the 'new specialists', each adding their own momentum to this divisive process. This has gone hand in hand with the development of a 'vacuum' of non-relationships which now embrace and challenge the subject itself.

The reason for at least part of this reductionist process is the development of new techniques which allow us to comprehend smaller forms within what to that time had been a homogeneous matrix. Once the techniques are available these sub-systems of form are amenable to study in their own right, each generating their own data and rules.

The contemporary proliferation of university departments of Biology and Schools of Biological Science, Wareing (1964), would appear to be a reversal of the main trend of reductionism. Within these

schools, courses such as biochemistry, biophysics, etc., are often regarded as more basic in that they provide common ground, a common understanding within the parent science. This is in itself a form of reductionism, it is however constructive in that it attempts to link rather than isolate the sub-systems of form.

One attempt at 'constructive reductionism' is found in Von Bertalanffy's General System Theory (1968), the central theme of which is best expressed in his own words from "Robots, Men and Minds" (1967). "General System Theory is a discipline concerned with the general properties and laws of systems! Within the context of Biology, General System Theory supposes that within and between each of the nesting 'black boxes' of form there are systems each of which has similar properties and obey, work to and exhibit common laws. It differs from earlier attempts at an all embracing theory of biology, such as Mechanism, Behaviourism, Vitalism, which each try to explain the phenomena of biology, they thus depend on knowledge of the system and are hence inductive. General System Theory is deductive an absolute statement of the rules or rule within which the system operates and through which it may be understood. It is at once obvious that a General System must be argued from the point of homology, the same rule or rules pertaining to all systems, it cannot be argued through analogy. Such a theory cannot sort analogies, it must create an homology.

The original aim of the thesis was to review the more

general literature in an attempt to define the general system for biology and apply it to the main problem of biology, that of the mechanism of evolution.

This basic problem relating to evolution is perhaps best summarised in Borel's (1956) work on Probability and Certainty. Referring to the famous monkey/typewriter analogy he states, "When we calculated the probability of reproducing by mere chance a work of literature in one or more volumes, we certainly observed that, if this work was printed, it must have originally emanated from a human brain. Now the complexity of that brain must therefore have been even richer than the particular work to which it gave birth. Is it not possible to infer that the probability that this brain may have been produced by the blind forces of chance is even slighter than the probability of the typewriting miracle?"

It is obviously the same as if we asked ourselves whether we could know if it was possible actually to create a human being by combining at random a certain number of simple bodies. But this is not the way the problem of the origin of life presents itself, it is generally held that living beings are the result of a slow process of evolution, beginning with elementary organisms, and that this process of evolution involves certain properties of living matter that prevent us from asserting that the process was accomplished in accordance with the laws of chance.

Moreover, certain of these properties of living matter also belong to inanimate matter, when it takes certain forms, such as that of crystals. It does not seem possible to apply

the laws of probability, calculus, to the phenomenon of the formation of a crystal in a more or less supersaturated solution. At least, it would not be possible to treat this problem of probability without taking account of certain properties that facilitate the formation of crystals and that we are certainly obliged to verify. We ought, it seems to me, to consider it likely that the formation of elementary living organisms, and the evolution of those organisms, are also governed by elementary properties of matter that we do not understand perfectly but whose existence we nevertheless ought to admit".

The thesis is set out in the order of progression of the work through study of the literature.

PART I

Appraisal of the validity of the concept of a general system and problems associated with it. (It was soon realised that one of the main problems was that of logic in approach. Study of the concept of logic appeared to be of importance and was therefore undertaken. An account of this is given in Appendix 1 as although it is of interest to the main part of the thesis it is not within the main stream of the discussion.

PART II

At this point in the study the experimental techniques described in Cymatics Jenny (1960) appeared to be of relevance to a fuller understanding of the problem. An experiment was

therefore carried out and the results are presented.

PART III

Consideration of the evolutionary theory in the light of the above.

The literature to which direct reference is made in the text is given together with a bibliography which lists the background reading carried out during the course of this work.

PART I TOWARDS A GENERAL SYSTEM

Study of a whole cross section of literature (see Bibliography) showed that the concept of time was common to all scientific endeavour, Haldane (1951). This appeared to be especially true for biology where the evolutionary development of living things is a function of time, Darwin (1859), Wells et al (1931), Thompson (1942), Blum (1951), Whitrow (1959), Olson (1966), Lerner (1968), O'Manique (1969). Consideration of the concept of time was thus taken as a starting point for the investigation.

THE CONCEPT OF TIME

The 'concept of time' has been subject matter for consideration and discussion over many thousands of years. The contemporary 'intuitively obvious' conception of time as a continual linear progression is historically speaking a very recent innovation. Although the development of this contemporary view is well documented, Whitrow (1961), Brandon (1956), it is key to an understanding of the following discourse and will therefore be outlined below.

Phase I

Many of the early and contemporary 'primitive' cultures viewed and view time as being cyclic in nature. The Mayan culture, Thompson (1969), of the 15th and 16th centuries best exemplifies this point. Time to the Mayan was divine. Each day, moment, year, etc., was a god unto itself, and each god carried his division of time as a burden in a long relay like

is a basic difference, comprehension is a one way state, comprehension by a system (the unique quality to a system). Whereas 'information' would appear to have a much more real existence, 'information' from a system passed to a system. It therefore becomes easier to step outside "the concept of the word 'information' and view it as a quantity of information" Yockey (1956) rather than the 'quality of comprehension'. If we do this we are at once faced with two sorts of information.

An example, in order to define a random system, more a priori questions must be asked in order to describe, understand the system, when compared with a less random system. It would seem that random systems must contain more information. That this 'contained information' (from here on designated by capital letters) is redundant to the comprehending system does not matter, it is part of the whole.

The basic problem is the system of containment, This systematised, quantified, integrated part of the information, is the information which is comprehended by other systems. The conveyed information becomes a system with its own quality (with its own logic) which can be understood. The error in any system is the other 'states', the rest of the INFORMATION that is excluded, or that is not comprehended by the integrating system. (Time is never comprehended, the systems are comprehended thus allowing the concept of time). The problem can perhaps be restated as follows: The greater number of allowed states in which the components of a system

procession. The burdens of the multitude of gods signified a particular omen that was calculated in the light of the overall influence that the particular combination of gods exerted at the moment in question. Such combinations were expected to repeat themselves in exact combinations every 260 years. Thus past events were studied and considered to repeat themselves ad-infinitum.

Whether the changing of the seasons or the awareness of birth and death, provided the stimulus for such reasoning is difficult to deduce. However there is little doubt that some natural cyclical process must have been the environmental stimulus which resulted in this idea.

Phase II

The influence of astronomy (the study of celestial occurrences) was originally emphasised in the Chaldean culture. The basic idea of the Chaldeans, Brandon (1965), was that all events on earth were influenced by the celestial bodies. The origin of the present naming of our seven day week has been traced to the discovery by the Chaldeans of the five planets together with the sun and moon. It was in the third or fourth century A.D. that the Christians changed from the simple numbering of the days of the week to the naming of the days as advocated by the Chaldeans.

Phase III

The Hebrew and Zoroastrian Iranian philosophers by way

of their progressive interpretation of historical occurrences provided the origin of the Christian concept of time, Brandon (1965).

Phase IV

The Christians, Case (1943), Quispel (1954), enforced and extended the linear view by regarding the Crucifixion as unique, thus never subject to repetition. All subsequent events were also considered as unique and non-repeating. Man now had a say in his destiny, whereas the cyclic view predefined over destiny. Thus the linear view of time confronted and eventually replaced the cyclic view. (It is interesting to note that the cyclic view of time was polytheistic, whereas the linear view of time was monotheistic).

Phase V

Up till the 17th and 18th centuries, philosophy, literature, art and culture in general abounded with mixed or singular approaches to the cyclic and linear concepts of time. However from the beginning of the 17th century the cyclical view of time was gradually replaced by the linear view. Through the work and thought of Kepler (1571-1630), Boyle (1627-1691), Pascal (1623-1660), Leibnitz (1646-1716), Barrow (1630-1677), Loche (1632-1704) and the invention of the mechanical clock by Huygen, the linear concept of time became firmly entrenched in modern philosophy. Before the introduction of the mechanical clock the linear conception of time was as something discontinuous and uneven. Then with the invention of

the mechanical clock (which was to provide the bases for the mechanistic conception of nature in natural philosophy) time acquired its characteristic of continuity.

Mathematics and Time

The obvious analogy of linear time and mathematics can be traced to Galileo and his consideration of the periodic oscillations of the pendulum. His theories on motion found in his text, "Discourses on Two New Sciences" (published between 1636-9) implied the concept of mathematical time with its characteristics of continuity, constancy and uniformity.

The earliest explicit statement of the concept of time is found in Barrow's "Geometrical Lectures" (1735). Barrow's concept possesses characteristics that were analogous to a mathematical line with regard to its continuity, uniformity, equal segmentations and length, the additive nature of each segmentation to produce a continuous whole. Newton, who succeeded Barrow to the Chair of Mathematics at Cambridge in 1669, was greatly influenced by Barrow's concept of time and in his text "Principia" (1687), he adds an additional character to the concept of mathematical time. This character being the absolute existence of time in its own right. In his own words: "Absolute time and mathematical time of itself and from its own nature, flows equably without relation to anything external".

The Philosophical Challenge

The world of philosophy, led by Leibnitz, challenged Newton's concept with great vigour. The reason was that the concept of the absolute nature of time created a vast number of difficult and perplexing philosophical problems. Leibnitz (1968) advocated a different characteristic to replace Newton's absolute, yet he did not challenge the whole body of propositions up to and including some of Newton's ideas dealing with the linear concept of time. Leibnitz proposed that the human species defines time from and by the presentations of phenomena but that phenomena are not derived from time in the absolute sense. This idea acquired the title of "The Relational Theory of Time", Margenau (1950).

The most recent addition to the linear concept of time was made by Einstein (1956, 1964) in his "Theory of Relativity". In the pursuit of his studies on the phenomena of motion and light, the problem of 'instantaneous occurrences' of phenomena as experienced by observers in different geographical locations became apparent. In his "General Theory of Relativity" Einstein neutralised the idea of time being universally simultaneous for all mankind regardless of geographical placement and positioning. The ordering of events depend upon the observer and the relationship that exists between space and time, Eisenhart (1966), a relationship which is so intimate that one complements the other. Thus the concept of space became an integral part in the conception of time and as Minkowski (1923) has pointed out, "no one has ever

noticed a place except at a time nor yet a time except at a place".

Perhaps the most important part of that statement is the 'no one', the acceptance of a system which delineates both time and space. The great advancement in the measurement (delineation) of time with the invention of the caesium clock by Essen, Whitrow (1961), is of interest. The caesium clock works on the principle that the caesium atom produces electromagnetic waves of about 9,200 megacycles per second corresponding to a wavelength of about 3-4 cm. The waves are a result of the change in direction of the outermost electron that the caesium atom possesses. Small amounts of energy are used to change the direction of the spin so that it is opposite to the spin of the nucleus. In a very short time the electron again reverses its spin to coincide with that of the nucleus, and in the process an electromagnetic wave is produced which may be picked up and amplified. The error in such a clock is about one second in 30,000 years. It should be noted however that the error is calculated in relation to our previous methods (celestial, astronomical, mechanical) of delineating time. The caesium clock is in essence a refinement of predicting our human imposed delineations.

Here is the basis of a paradox in logic. Time, considered as a circular phenomenon allows the prediction of other phenomena, "it has happened before, it will happen again". The planets revolve, day follows night, eclipses can be predicted,

circular time allows absolute rules, condoning divination. Time considered as a linear phenomena, does not allow absolute prediction, divination is replaced by hypothesis, hypothesis based on statistical probability. However as soon as time is measured, either by reference to the revolution of the planets or the change in spin of the electron, it is quantified into units of repetition. One second follows another, each second is similar, quantification is circularization, circularization supports divination.

Time is the basic delineation, but as soon as we attempt to contain it, quantify it, measure it, we conceptualisê sub- systems each with their own predictive logic. Restated, time is an absolute for all systems, an homologue for all systems. The paradox is, that time measured by any one system becomes a unique function of that system. The error lies in measurement. It is interesting to speculate that as time itself has no existence outside a system of quantification, the error and time become synonymous.

Knowledge Versus Hypothesis

In the year 1924, Heisenberg (1969a & b) introduced a new and provocative proposition into theoretical physics. Heisenberg's proposition which has come to be known as the 'Uncertainty Principle' states that any act of measurement disturbs the process to such a degree that it introduces changes and error to the true quantities of the process under consideration. To measure any velocity 'X' of a

particle, a short x-ray wave length is required. The particle retracts or recoils from the impinging ray, thus producing uncontrollable effects on the momentum of the particle under observation.

Bohr extended Heisenberg's Principle to define the whole context of physics, Eddington (1935), a description containing only propositions of conscious knowledge and observations of phenomena. Not 'the' in the absolute sense knowledge, knowledge of a phenomena or particle. Von Neumann (1955) provided the necessary theoretical (mathematical) logic that substantiates the existence of the proposition of Heisenberg and Bohr.

Thus the classical view of cause-and-effect was relegated to a pejorative form of consideration and the laws of probability were elevated to their present meliorative form of acceptance. Divinitive physics based on logical sub-systems was replaced by laws delineated by statistical probability, Margenau (1950), the laws of quantum mechanics. As far as quantum mechanics is concerned, the idea of a physical reality is renounced as a metaphysical indeterminate.

The discussion has in fact returned to the problem of Minkowski's assertion, "no one has ever seen a place except at a time, nor a time except at a place". Again the most problematical part of the statement would appear to be the 'no one', that is the system which interprets the phenomena

or at least the statistics. The accrual of statistics on recurrent phenomena (eg. the revolution of the planets) leads to quantification and hence the acceptance of the concept of time as a quality of the system. Einstein has indicated that quality is a unique function of the system of interpretation. It seems impossible to get away from the fact that once a system has been chosen it (1) assumes unique features and (2) excludes other systems.

Quantity, Quality and Systems of Interpretation

Quantitative data (statistics) allow systems of repetition to be understood, to be given quality. If there is no repetition, no pattern, no 'system', accrued statistics cannot reveal quality. No pattern, no system, no repetition means disorder, and disorder to the system of interpretation is synonymous with ignorance.

Form, order, pattern, system then becomes synonymous with 'information' (neg-entropy of Schrödinger, 1967) and though the system of interpretation is synonymous with comprehension, comprehension of quality. But is comprehension the same as 'information'? The answer is no. The error is in the anthropomorphism, the system, which integrates the information. (In mathematical logic integration is the method by which something whole, or undivided, is produced.) It must be accepted that within the word 'information' there is also this anthropomorphism, eg. information, to what? However there

is a basic difference, comprehension is a one way state, comprehension by a system (the unique quality to a system). Whereas 'information' would appear to have a much more real existence, 'information' from a system passed to a system. It therefore becomes easier to step outside "the concept of the word 'information' and view it as a quantity of information" Yockey (1956) rather than the 'quality of comprehension'. If we do this we are at once faced with two sorts of information.

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can exist, the greater the number of questions which must be asked, in order to delineate the states in a comprehensible system. That is, the more random the system is, the greater is the contained INFORMATION, but the less is its conveyed information.

Any system (form) conveys INFORMATION, but only information relating to that system. The information is more fundamental, because under another delineation it can convey other information. Systemization is the structuring of the information, but the system never contains all the information. This is implicit in Godel's theorem, Newman (1960), "that a mathematical system cannot be self-descriptive, all the rules necessary for describing the system cannot be stated within the system".

It is interesting to speculate that statistical probability depends of accrued information, the chance of gathering sufficient information to allow 'statistical comprehension' increases with time. Time is thus again the error in any delineation. More time would allow further data to be accrued and hence other forms, systems, other parts of the information could become statistically meaningful (comprehensible).

Here is the basic problem of a general system:- A general system theory can only be formulated in relation to the available knowledge. Its limitations are thus set and it must be appreciated that (1) great care must be taken in

applying it outside that sphere of knowledge, (2) new knowledge must not be adapted to conform to the general system, but that the system must be modified to contain that knowledge. At this point in the study certain parallels in 'logic' become evident, these are discussed in Appendix 1.

PART II AN EXPERIMENTAL APPROACH

At this stage in the study the publications of Hans Jenny (1967, 69 & 70) in which he describes experiments carried out with a piece of apparatus, the Tonoscope, appeared to be of relevance.

The Tonoscope is an apparatus which not only allows form to be observed, but allows form to be manipulated, thus permitting the study of the processes of change.

The Tonoscope projects sound (acoustical vibrations which possess wave-like properties) onto a diaphragm. The diaphragm can be made of any type of material which is capable of transmitting the acoustical vibrations to the medium, which is placed on the diaphragm. The medium is randomly spread on the diaphragm (N.B. the medium cannot be perfectly random, as it is ordered with respect to the diaphragm and to gravity). Under acoustical stimulation the medium rapidly loses its two-dimensional randomness, and a comprehensible form takes shape on the membrane.

The form of the complex of vibrations of the diaphragm is translated by the medium into form which can be comprehended by vision of any of its extensions (photography, cinematography, art, etc.). The comprehension of the form can be extended by using any optical technique (stroboscope,

high-speed photography and magnification), e.g. any optical system between the signal of form and the integrating system, the complex of the human eye and brain.

In the sense of the above discussion, the media is the INFORMATION, a part of which is structured into information.

Pages AA-DD show the results of an experiment in which two Tonoscopes (a. round form (left-hand side of pages AA-DD; b. square form (right-hand side of pages AA-DD)) were used. In both cases the membrane was rubber and the media was sand. Full details of the experimental conditions are given in the following table:

<u>Page</u>	Round Form Tonoscope		Square Form Tonoscope	
	Photo	Frequency (c.p.s.)	Photo	Frequency (c.p.s.)
AA	a-1	165	a-11	165
AA	b-2	270	b-22	270
AA	c-3	275	c-33	275
BB	d-4	340	d-44	340
BB	e-5	425	e-55	425
BB	f-6	520	f-66	520
CC	g-7	610	g-77	610
CC	h-8	710	h-88	710
CC	i-9	820	i-99	820
DD	j-10	890	j-100	890
DD	k-11	960	k-111	960
DD	l-12	1200	l-122	1200

Tension: Round and Square (Form)

Tonoscope - 59 mm

The two series of photographs can be viewed as a record of change with respect to increasing frequencies. If an observer were given the photographs in random order, it would be a simple task to arrange them into a sequence of changes, a sequence of development of form. If the photographs are viewed carefully, the residual media can however, be seen existing in a more random state. This is made much clearer by viewing the coloured-fixed plate. (This was produced with coloured media (sand) and an adhesive coloured plate).

There is only one problem in all static methods of representation, a great deal is hidden. The kinetic phenomena displayed by the media are listed below:-

Kinetic phenomena of the media

- Pulsation
- Rotation
- See-saw effect
- Circulation, within the forms, figures, patterns.
- Constancy of the material in a system
- Integration effect
- Individuation
- Dynamics of eruption
- Dynamics of current flow etc.
- Conjoining and disjoining of a single mass
- The order of patterned areas
- The creation of figures
- The creation of forms

These 'effects' must be borne in mind, but further consideration of them at this point is unnecessary. The fact is that the more random matrix of INFORMATION is there subtending the information in the comprehensible form.

Returning to the two series, the totality of the INFORMATION remains, There are however, two important features of the two series:

(a) that in each series, at certain frequencies, the system of form (information) breaks up into sub-systems of form (information). The problem then becomes whether to study the sub-system, or the whole, or a combination of the two. It is important to note that if the sub-systems are studied separately, each possesses the same properties as the whole, INFORMATION and information. It is also important to note that although the sub-systems contain less INFORMATION, the form of the sub-system can be just as complex as the form of the original whole. Compare the sub-system ringed in Fig. L-122 with the gross form of A-11. So again the initial delineation of what system to study (what logic to use), becomes all important. In this case reductionism reduces only the context of the system, it does not necessarily produce simpler systems of comprehension.

(b) The difference, but parallelism, between the forms produced on the round and square form Tonoscopes.

The only difference in the 'developing' series (pages AA-DD) is the increased frequency (of input), which can be regarded as an increased number of disturbances of the membrane, hence media in unit time. This could be regarded as an increase in energy activating the membrane, hence the media. The 'free energy' of the media is increased (see list of kinetic

phenomena above), the INFORMATION of the system decreases, as more complex forms develop.

The Tonoscope thus allows at least some basic study of the phenomena of form. If an observer were given the photographs AA-DD in random order it would be a simple matter to arrange them in a sequence of the development of more complex forms. Given a time scale (and perhaps biological training) the concept of evolution would manifest itself.

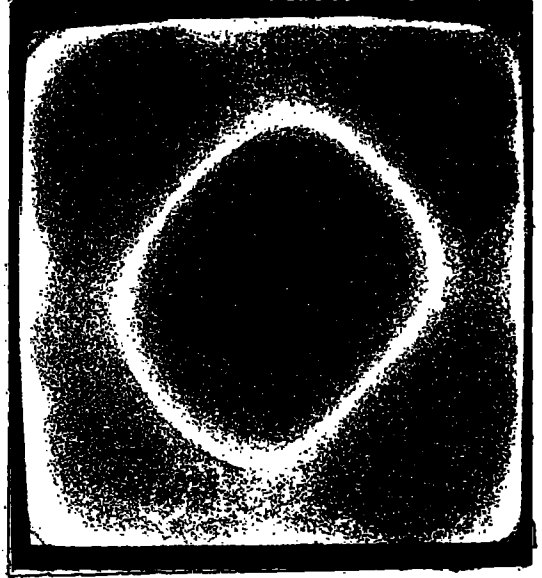
PAGES AA-DD

Experimental Data for the Thesis.

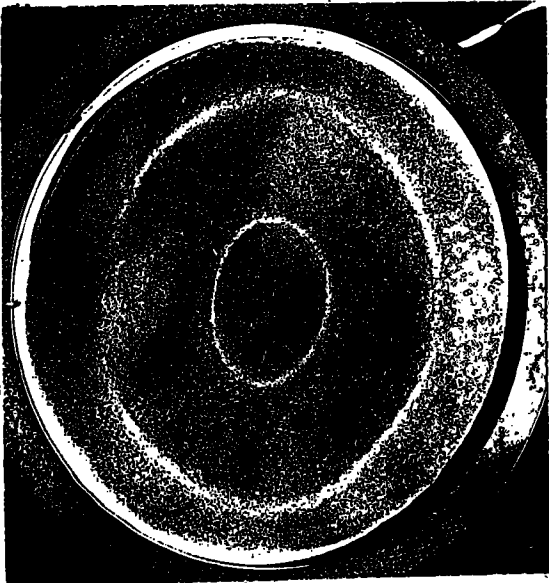
Tables provided in Thesis, Page 20.



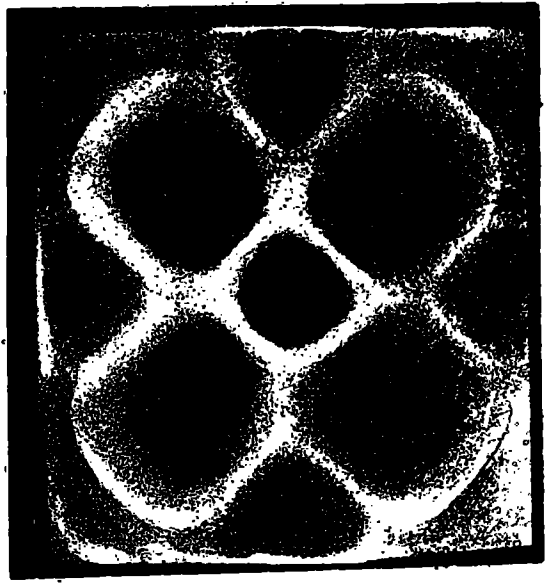
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a_11



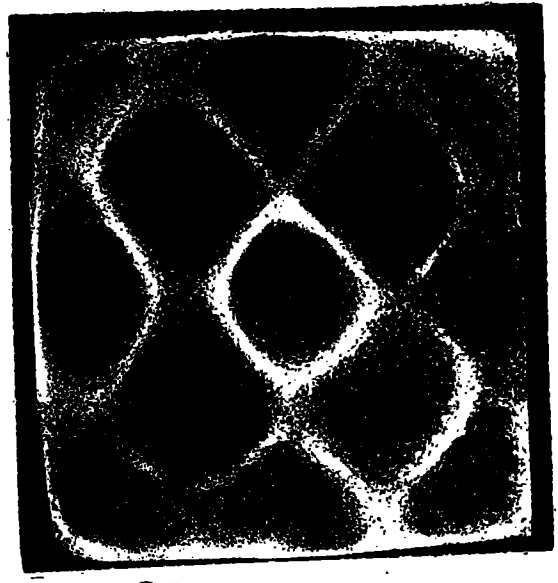
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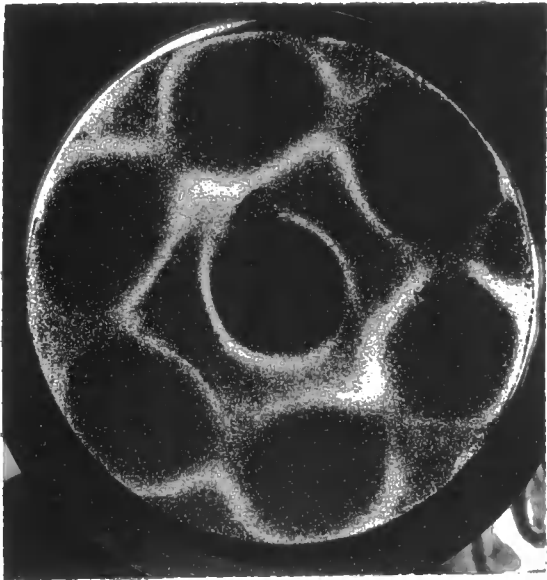
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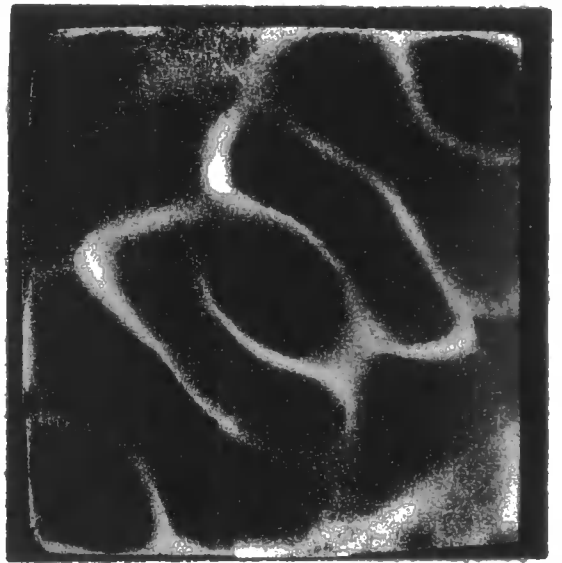
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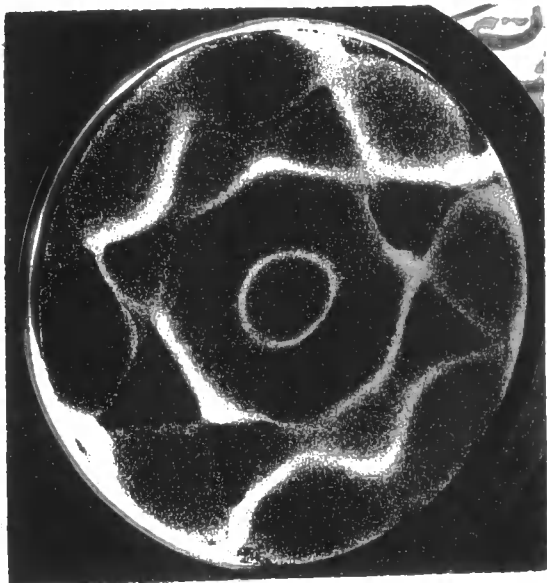
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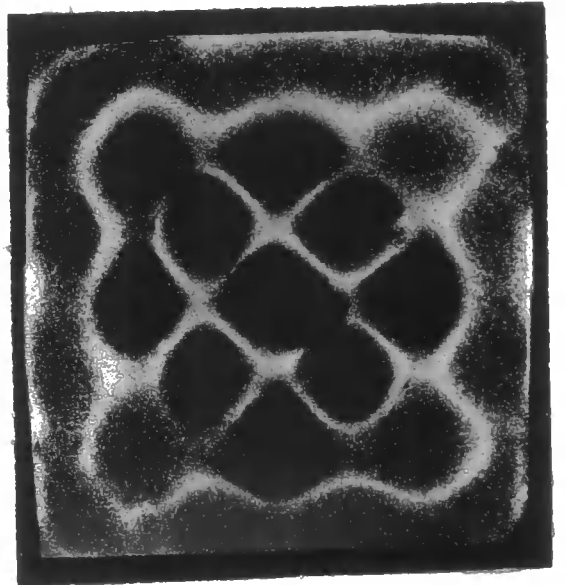
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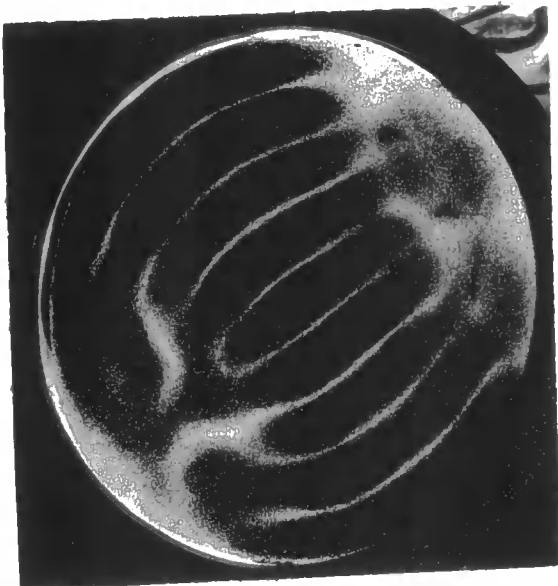
d_44



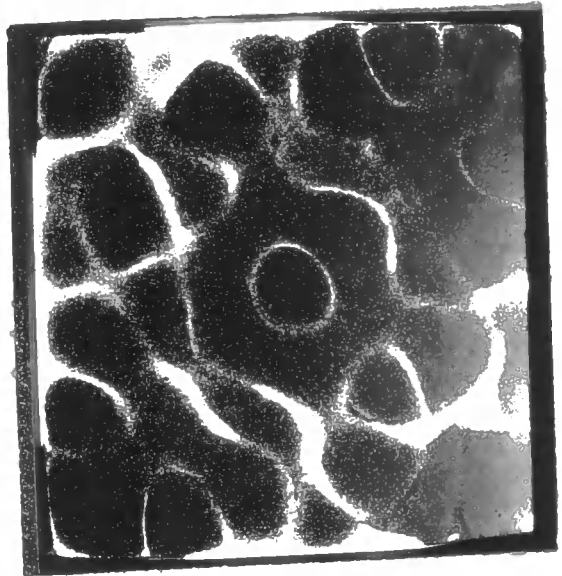
e_5



e_55



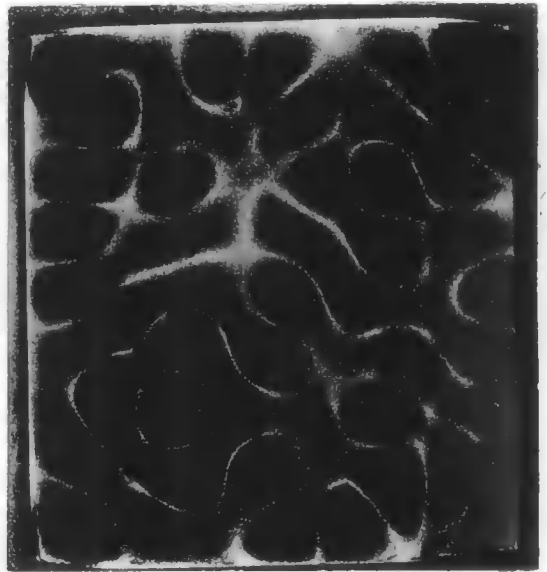
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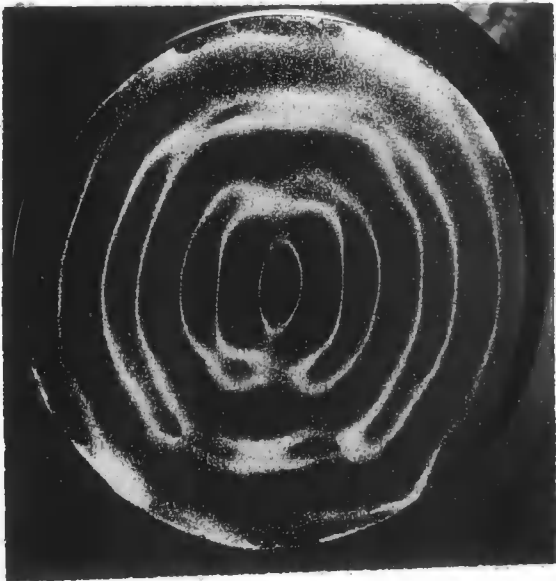
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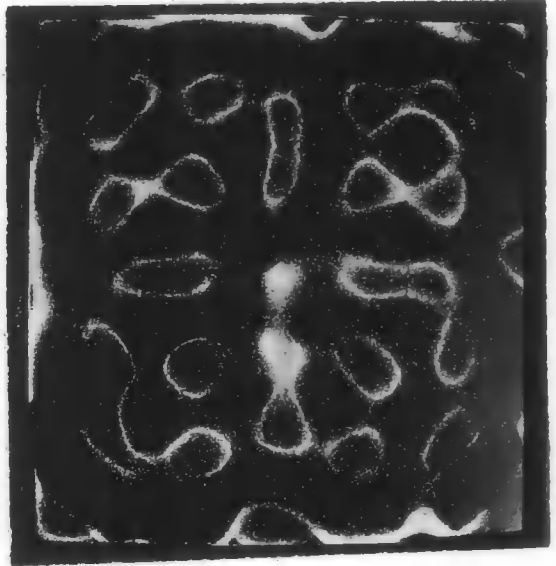
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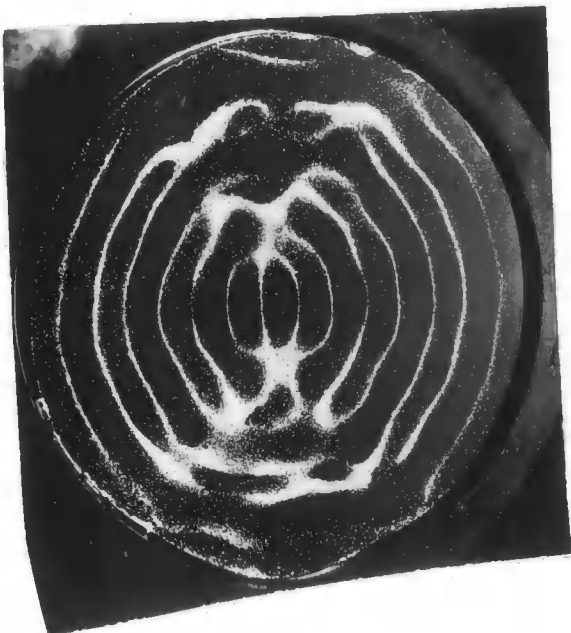
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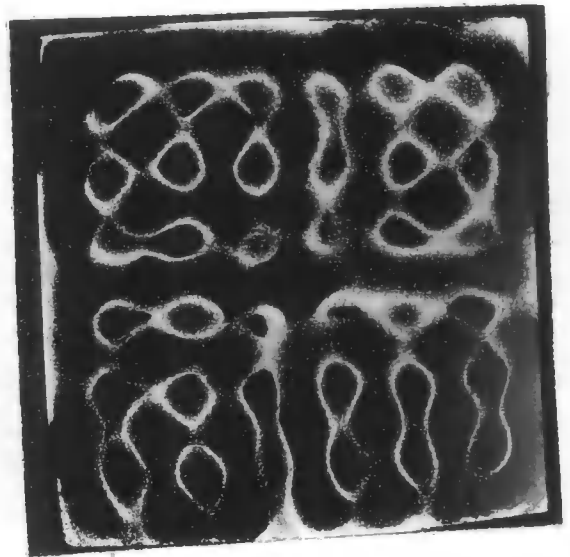
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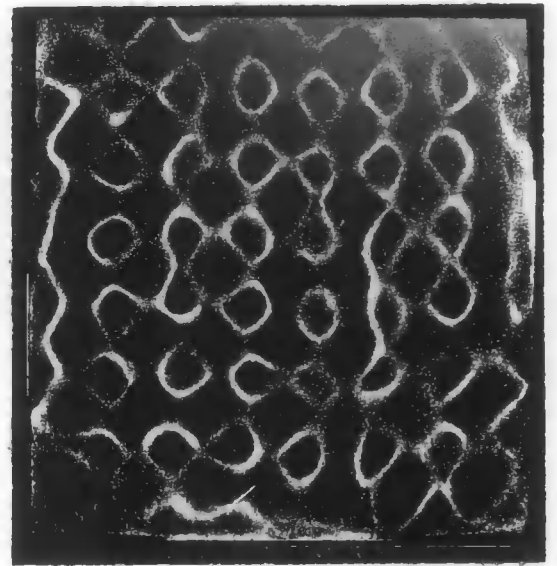
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i_99



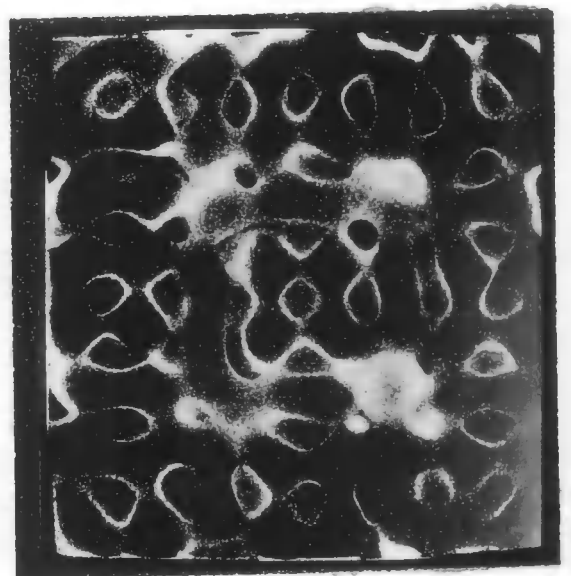
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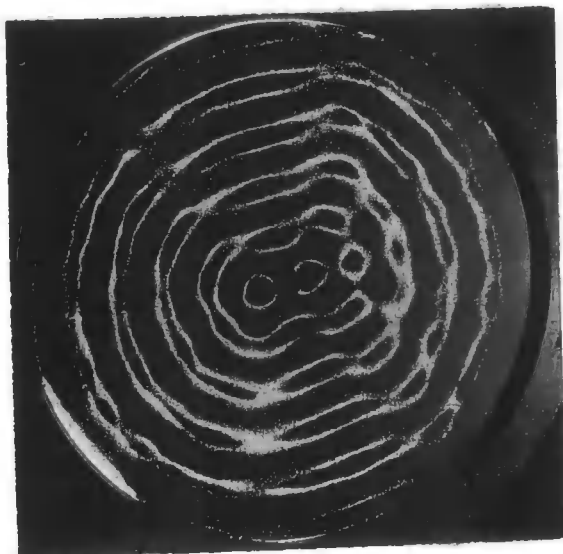
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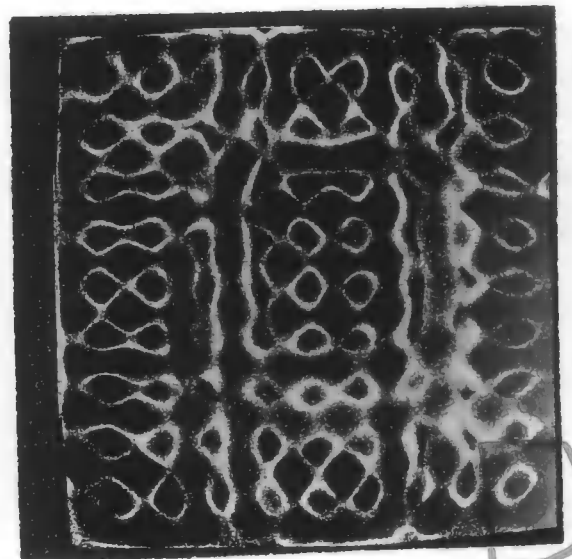
k_11



k_111



l_12



l_122

PAGE FF

Coloured Fixed Plate containing a Fixed
"Pattern" (sand), produced by a Specific
Acoustical Vibration by way of the
Tonoscope.



PART III BIOLOGY, EVOLUTION, A GENERAL SYSTEM?

Biology is the study of the form of living things, Thompson (1942). Its various sub-disciplines study form at different levels. This has in the main been made possible by the development of apparatus and techniques which have increased the resolution of the human eye and allowed other structures to be seen or comprehended where before no structure or form was comprehensible. Biology contains one main linking logic, a general system called 'evolution', Simpson (1965). Only this provides a wholistic counterbalance to the reductionist approach which typifies the subject today.

By reviewing analogies in the developed forms seen against the background of time it elegantly explains the diversity and diversification of organisms. This is implicit in the title of Darwin's main work on evolution-"On the origin of species by means of natural selection". The concept of selection invokes something to be selected from, it does not explain the evolution of that something. Darwin's publishers added the sub-title-"Preservation of favoured races in the struggle for life", which was bastardised through a statement of Wallace, "that the fittest would survive" into the dogma of "survival of the fittest in the struggle for existence". Yet it is only this dogma that really attempts to identify a drive (something to be struggled for) behind the evolutionary process.

Neo-Darwinism has continued the reductionist approach to the problem, Waddington (1969, 1970). Within the subsystems of the gene pools, it invokes passive natural selection through differential reproduction as being the mechanism of diversification. The mechanism for diversification is however not the same as the drive of evolution.

The system of evolution is manifested and understood as change through time. The importance of the system of evolution would thus appear to be the transformation of one form into another (the origin of species) producing diversity both in space and time. Herein lies the paradox. In the Darwinian sense, that which has changed has not survived, so it does not bear the stamp of fitness. Likewise that which has not changed, although it bears the stamp of success, has not evolved.

Returning to the experiment. The only difference in the 'evolving' series (photographs AA-DD) is the increased frequency of input which can be regarded as an increased number of disturbances of the membrane, hence media in unit time. The free energy of the media is increased (see the list of kinetic phenomena), the INFORMATION decreases as more complex forms develop. The greater the amount of energy dissipated by the membrane the more complex is the total form produced. This is reminiscent of the living state. Life maintains high levels of free energy and low levels of entropy (Schrödinger 1967). Evolution moves to more complex systems which require

a greater flow of energy for maintenance.

Whichever view of evolution is taken, two features are held in common. (1) An increasing complexity. (2) An increasing dissipation, (degradation sensu Clausius (1865)) of energy. Heat is considered as the most degraded form of energy, in that the energy represents the random movement (agitation) of molecules, the movement slowly decreasing as the temperature approaches 0°A. This reduction in movement reduces the chance of molecular contact and hence of chemical reaction which would produce more ordered systems.

The evolving system is placed under the constraint of increasing degradation of energy, the heat released being of key importance only in the life processes of the complex, advanced homiotherms. Any system placed under a constraint must according to Le Chatelier's Principle, De Groot's (1952) act to nullify that constraint.

Within the surface environment of earth, with its range of temperature which is low enough to allow the existence of macromolecules, the evolving system can only respond to nullify the constraint of increased degradation of energy by storing it in the form of ordered systems of macromolecules, Bellamy & Clarke (1968). If this is accepted, then once a mechanism for the fixation of light energy had evolved, the process of evolution was set in motion. The evolving system,

that is the total system, not the individual, population nor gene pool, but the biosphere, moving towards a state of maximum degradation of the energy incident upon it.

The dogma of evolution should not be survival, it should be potential. Not the survival of the fittest, but the fact that all the time there is potential (eg. incident energy or biogeochemicals) which are unused or which could be used more efficiently, then there is the 'drive' for evolution to make use of that potential.

The fact that the efficiency of photosynthesis appears to be pegged at around 1.6%, Meyer et al (1960), points to the fact that evolution has not yet produced a more efficient system. The reason for this could be either that it has failed to evolve the necessary control of a more efficient system or that the potential of the dependant living process is limited by factors other than the capture of energy. The apparent 'conservatism' of evolution at the level of functional biochemistry borne out by,

(1) the fact that many of the important constituents of metabolic pathways are common to all organisms, and

(2) the discovery of the building blocks of key organic molecules in pre-cambrian rocks almost points to the immutability of the most important features of evolving organisms. A more logical interpretation might be that the full potential of the metabolic pathways even at this level of inefficiency has not yet been realised by the evolutionary process, and thus there is no selective advantage in more efficient.

metabolic systems.

Evolution must therefore be considered as the process by which more space both horizontally and vertically has been exploited by the living process thus intercepting and using a greater amount of the incident energy. This has required movement from the sea onto the land, the differentiation of members of the food web, primary producers, herbivores, carnivores, decomposers, parasites, etc., Odum (1956). The development of xeromorphs, heliophytes, sciophytes, of trophic and nastic movements, and of the arboreal and epiphytic habitats. The evolution of structured units and controlled systems at all levels from the sub-cellular to the ecosystem, each playing an important integrated role in the whole process.

We cannot isolate the process of speciation from the overall process of evolution of the biosphere. Odum's definition of ecosystem is of interest in this context:-

"Any area of nature that includes living organisms and non-living substances interacting to produce an exchange of materials between the living and the non-living parts is an ecosystem" Odum (1956).

With appropriate modification this is equally well a definition of an organism, an ecosystem or the biosphere. It is interesting to remember the early acceptance by certain ecologists that ecosystems could be regarded as quasi-organisms, Clements (1928). This view was strongly challenged and fell

from favour. However more recently with the actual measurement of the rates and levels of exchanges of energy and biogeochemicals, Phillipson (1966), the concept is once again coming into favour, or at least it is being realised that ecosystems and organisms are amenable to the same type of study, Duvigneaud et al (1970). Evolution is one process but it is comprehensible at a number of levels.

Darwinism has focussed the attention of biology on one level, the diversity of organisms. Neo-Darwinism attempts to understand the process of diversification by study of the gene pools. Evolution has thus tended to be regarded as a function of a specialised part of the whole system.

Henderson (1913) perhaps came closest to the idea of evolution as a single unified process in his statement "Darwinian fitness is compounded of a mutual relationship between the organism and the environment. Of this, fitness of the environment is quite as essential a component as the fitness which arises in the process of organic evolution". His book details the components of the earth's crust (geochemicals) which are fitted to and hence are fit for the living process. The basic argument in its crudest terms is that if arsenic had been more abundant in the earth's crust then evolution of the living state would either not have 'happened', or would have 'happened' in a different way, perhaps producing different forms. Henderson thus focussed attention on the importance of the living state.

Recently ecology has begun to regard diversity as an important feature of ecosystems, Margalef (1968), the maturing ecosystem (cf. evolving) passes to a state of greater diversity and greater stability. Calculation of the ecologist's indices of diversity are usually based on the basic units of the Linnean system of nomenclature, the species, that is the end product of the Darwinian process. Such indices are meaningful only if Gause's Principle that no two species can occupy the same ecological niche, Gause (1964), holds true. Only then do the evolved differences between species have any functional meaning within the ecosystem.

The forms (phenotypes) which biologists study are no more than 'screens' between the basic similarities of all organisms, the living state, Ling (1962) (as yet undefined), and the environment. Part of the information of each gene pool relates to the living state, the biochemistry which is basic to the majority of organisms of all phyla. The accrued evidence indicates that this has changed very little and thus has survived through time. The rest of the information in the gene pool relates to the 'phenotypic screen', it is this part of the information which is changing.

Information, Change and the Organism

In the evolutionary process, the zygote of each individual within the gene pool contains all the genetic information relating to the living state and its expression through the phenotypic screen. Development goes hand in hand with

replication of this information, but during embryogenesis more and more of this information is rendered redundant as cells are 'moved into positions' where they perform specific functions, Driesch (1937). The higher up the evolutionary scale, sensu Darwin, the greater is the amount of redundant information present in the individual at maturity. In the same way the higher up the evolutionary scale, the greater is the restriction and specialization of reproductive structures and at least in the animal kingdom the less is the possibility of regeneration of lost parts.

This evolutionary specialization goes hand in hand with alleviation of restriction of habitat. Definition of habitat is of key importance for the following reason. The pro-caryotic organisms without doubt are found in the greatest diversity of habitat, being found from the tropical seas to the edge of the polar and alpine ice deserts. Within each habitat they are restricted, or at least their period of growth and development is restricted, to those areas or periods when free water is present.

The major factors limiting the 'living state' and hence facing the evolutionary process are the limitations imposed by the environment, light, temperature, atmosphere, water, Lundegardh (1931). The various forms we study, the phenotypic screens, are the successes of evolution in relation to these factors and to these factors as modified by other biota. Evolution is the process whereby the potential of the environment is 'exploited' by the living state. This is accomplished by

environmental screening by the phenotype. The 'struggle', whether active or passive, is not for existence, if it were the procaryotic organisms would reign supreme or better still some super organism would be found. The 'struggle' is for maximum expression of life, maximum flow of energy.

The process of evolution is a composite of two parts, (a) increase of the living state on earth, in essence increased cycling of biogeochemicals, and (b) an increase in the diversity of the phenotypic screen adapting to, and overcoming, the environmental limitations. Energy is the 'prime mover', the potential, the opportunity for increase of 'life'. Natural selection is the mechanism which 'sieves' that opportunity.

Recapitulation

As the earth cooled chemical systems came into existence and the elements and compounds, now found in the earth's crust, (geochemicals) were formed. As cooling continued, compounds like water were able to exist in the liquid state and the hydrosphere came into being. At some point in the latter part of the earth's history (when the temperature environment was low enough to support the existence of macromolecules), chemical systems developed which were capable of self-replication. The energy necessary for the process of synthesis being derived from oxidation-reduction reactions. The main constituents of these new chemical systems were C, N, O, H, P and S which together with varying amounts of

many of the other chemicals of the earth's crust were entrained into the process and a new global system, a system of biogeochemical cycling, was initiated, the energy necessary for the cycling being derived from the sun. Evolution was thus set in motion, a process through which the living chemicals were to be 'carried' to every part of the globe where water exists as a liquid and where geochemicals are available to that liquid medium.

The unit of evolution is the unit of biogeochemical cycling, organism, ecosystem, biosphere. The limitation is the first raw material usually a geochemical which becomes in short supply and hence limits the living process (cf. limiting factors, Odum (1956)). Evolution can then respond by producing a system which overcomes this limitation. This response can either be at the level of the organism through biochemical or biophysical evolution, or at the level of the ecosystem by recruitment of some organism into its food or decomposer chains which uses or recycles the limiting geochemical more efficiently.

The zonation of the terrestrial ecosystem on a world scale in relation to macroclimate both with respect to altitude and latitude, Tundra, Taiga, Deciduous forest, etc., indicates that the main limiting factor is growth period which is mainly controlled by temperature often acting through water and hence nutrient supply.

The presence of specialised ecosystems, sand dunes, salt-marshes, reedswamps, etc., within all the major vegetation belts of the world, Daubenmire (1947), points to the limitations placed on the process of evolution by extreme environments. However the theories of succession and climax, whether mono-, Clements(1928), of poly-, Tansley (1939), as yet neither proven or disproven, indicate that given time even these limitations can be in part overcome.

Modern developments in ecology stemming from Lindemann (1942) which are aimed at measuring the productivity of living systems in relation to biogeochemical cycling allows at least some empirical appraisal of this. Comparative data for the productivity of the climax systems developed by the process of succession in three contrasting habitats in one climatic region is given in Table 1. The three habitats and 'climax' forest systems are:-

- (1) Mixed oak woodland on alluvial soil,
- (2) Birch woodlands as the terminal phase in hydroseral development in a drainage lake which received during its development mineral supply from the ground water draining through it.
- (3) Pine woodland developed on peat which terminated the process of succession in a seepage lake. The mineral supply to the climax system being derived solely from the rainwater falling directly on the system. That is the climax system is isolated from the supply of nutrients from the parent substrate or mineral soils.

Data from Rodin & Bazelivich (1967) and Reichle (1970).

TABLE 1 Productivity and Nitrogen Uptake
of three Climax Systems

Climax Ecosystem Type	Mixed Deciduous	Birch	Pine
Net Annual production gms/dry wt.	1440	750	62
Nitrogen uptake gms (annual)	12	6	0.5
Production/ Nitrogen uptake	120	125	124

The production figures speak for themselves indicating the limited potential of the more extreme environment. The figures relating to nitrogen uptake are of interest in that they indicate that not only is nitrogen limiting to the process, but that at least at the level of the climax system there is a fixed relationship between abiotic and biotic potential. In all three a certain amount of nitrogen giving rise to the same amount of production of biomass. A lot more accurate data of this type is necessary before such deductions can be regarded as anything more than wild

speculation. It is hoped that the International Biological Programme will provide meaningful data on the required extensive scale.

However in the light of the foregoing discussions it would seem valid to suggest that the concept of natural selection and survival of the fittest supported by the concept of exploitation of potential would give a better understanding of evolution, and hence of biology. Perhaps stated together as follows "evolution is the process by which the full potential of the living state on earth is realised through natural selection, the whole system moving to a state of maximum degradation of energy in compliance with the laws of thermodynamics".

It is suggested that this statement approaches the definition of a general system for biology in that it (1) attempts to accommodate the more recent knowledge relating to the living state, (Knowledge which has been expressed in statements like "In my philosophy there is but one living matter that has overgrown this globe's surface, taken up different shapes, sizes, complexities and colours, adapting itself to the various conditions" Szent-György, (1960)), (2) attempts to relate knowledge of all systems from the molecular to the biospheric. Whether the laws of thermodynamics as applied are in reality the elementary properties of matter, the importance of the acceptance and verification of which were indicated by Borel (1956) (see introduction), is

unfortunately impossible to say.

The dilemma of acceptance of any one concept, any one system, as shown in sections 1 and 2 of the thesis, and in the Appendix is still with us and is best summarised by the optical illusion in the preface. If it is possible to conceptualise not the faces nor the vase but the composite picture of faces and vase then it is possible to have a (deductive) general system.

APPENDIX 1 AN APPROACH THROUGH LOGIC

Philosophy is the pursuit of knowledge of things and their causes. Science is systematic and formulated knowledge. Logic is the science of reasoning.

In logic the structure or order whether displayed or conceptualised is called the form. The particular medium that displays a form is called the content, this may be physical, auditory, tactile, etc. The act of considering a particular form apart from its content is called abstraction and the symbolizing of it by name is called the act of conceptualising. The concept of any form is the manner in which it is put together with no reference to the content. Concept is a component of elements and relations.

(Biologically it must be remembered that form can only be appreciated by an individual through the channels, auditory, visual, tactile that the human species has evolved in relation to his environment and to the store of knowledge that individual has acquired through a period of contact with that environment.

We must accept that when anyone sees a circle, he sees a circle, this is an evolved characteristic, communication of the fact that he has seen the circle (form) to another individual who has not seen it and is incapable of seeing it is the problem. Here logic must take over the role of the evolved receptor.)

Certain relations can hold one, two or more elements together, ie. 'between' is a relation which requires three elements to be complete.

cf. I am between the table and the chair.

Elements-I, table and chair, relation-between

It must be noted that the whole could be regarded as a single form and could be used as such as an element in another relation. The numbering of elements a relation requires so that its expression is complete is called the adicity of the relation.

A statement that asserts that:-

- (a) a relation is indicated,
- (b) the required number of elements are present,
- (c) the relation plus the elements assert themselves, that is, that the relation holds regarding the elements being related, is called a proposition, Whitehead & Russel (1967), or sentence, Tarski (1941). Proposition will be used throughout this work.

An example of a proposition is as follows:

The car is red.

The man has brown hair.

To avoid the confusion that is encountered when verbal forms (phonograms) are used, ideographic symbols are used in their place.

phonogram - The car is red.

ideogram - The car - interpretation a.

red - interpretation b.

is - interpretation c.

Thus, the ideogram $a b c$ replaces "The car is red".

The power of clarity exhibited by the use of ideographic symbols becomes apparent in the following example:-

phonogram - I played games with the boys.

ideogram - From stated knowledge let us assume that the number of boys is four.

I - interpretation a.

boys - interpretation b c d e

played games with - interpretation α

Therefore:

$a \alpha (b + c + d + e)$

$a \alpha b \quad a \alpha d$

$a \alpha c \quad a \alpha e$

$a \alpha b (c + d + e)$

$a \alpha c (b + d + e)$

$a \alpha d (b + c + e)$

$a \alpha e (b + c + d)$

Thus, within the phonogram "I played games with the boys", is telescoped a number of possible propositions (forms)

$a \alpha (b + c + d + e)$ - I played games with (all of the boys combining as a group to challenge me).

$a \alpha b)$

$a \alpha c)$

$a \alpha d)$

$a \alpha e)$

- I played games with (all the boys separately).

$a \alpha b (c + d + e)$ - I played games with (all

of the boys where ONE has the backing and guidance of all the rest, thus producing a superior player).

It is this telescoping of possible propositions that distinguishes Aristotlelian logic with its use of, (a) phonograms, and (b) reduction of all phonograms to fundamental subject-predicate relationships, ie, all statements are reduced to 'is' form, as compared to Symbolic (or mathematical) logic, with its use of symbols to designate (a) elements (the parts that are being related to each other), and (b) relations (the certain something that holds the elements together).

In any train of thought, elements and relations are not united in a random fashion. Certain elements are united by certain relations. For example:-

I swam the lake

I ate the lake

I drank the lake

I grew the lake

elements: I, the lake

relations: swam, ate, drank, grew

It becomes clear that only certain elements and relations can be considered as abiding with one another.

A group that is formed when:

(a) a relation plus all the possible meaningful elements that may be used;

(b) elements plus all the possible relations that may

be introduced;

is called a context. By translating (a) in the above sentence into an example, further terminologies of discourse can be introduced. For example:-

elements: five people a b c d e

relations: to the left of = interpretation α_2

Therefore:

a α b

b α c

c α d, etc.

Each one of the above ensembles of two elements plus a relation produces an elementary proposition (form, order). The subscript 2 enforces the knowledge that, this particular relation requires two elements for its completion. Whether or not each and every elementary proposition is valid is determined by information (a priori) that is stated beforehand as being truth.

That is: a α b is true

b α c is true

Therefore: c α b is false

b α a is false

Therefore, with certain knowledge of a few of the elementary propositions, the truth value of others are automatically fixed.

The logical relationships between elementary propositions which permit the "automatic fixing of truth values of others" are as follows:

(a) By the use of the word "and" a logical relation or conjunction or joint assertive between elementary propositions is created.

$a \alpha b$ and $b \alpha c$ therefore $a \alpha c$

The symbol that usually expresses "and" is "."

Thus, the proposition rewritten:

$a \alpha b . b \alpha c$ therefore $a \alpha c$

(b) The disjunction of elementary propositions by the assertion of :- (a) "either" one "or" the other

(b) or "both"

That is: either $a \alpha b$ or $b \alpha a$ is false

or both $a \alpha b$ or $b \alpha a$ is false.

That is : $(a \alpha b) \vee (b \alpha a)$ (\vee = disjunctive relationship).

If $a \alpha b$ is stated as being true, then $b \alpha a$, by fact or implication or preclusion, is known to be false.

The symbol \supset is used to indicate: implication or preclusion.

Therefore: $(a \alpha b) \supset (b \alpha a)$

The symbol before any elementary proposition means the following:

$(b \alpha a)$

$b \alpha a$ fails

It is false that $b \alpha a$

} All mean the same thing

Thus, once the elementary propositions are formed from the given context of elements and relations, the three relations that exist among elementary propositions are employed.

The three relations (a) Conjunctive "."
 (b) Disjunctive "v"
 (c) Implication or preclusion ">"
 are called by many logicians "logical constants".

Within the limits of a given context (elements and relations), elementary propositions are formed. With the implementation of the logical constant between the given elementary proposition, plus the truth value of certain elementary propositions (in the above-mentioned given context), a process has been partially instituted. Such a process taken to its completion produces a system.

Thus, a system is produced as follows:

(a) Elementary propositions formed from a given context (of elements and relations).

(b) Prestated truth values regarding certain elementary propositions are stated.

(c) In the light of the given information the elementary propositions are related to each other using the logical relations of conjunction, disjunction, implication, thus, producing a structure where all elementary propositions acquire a truth value of "truth" or "fallacy", thus producing a system.

Certain systems wherein

(a) the truth values of a few elementary propositions were given as 'known'

(b) with the use of the logical constant the truth

or fallacy of all the other elementary propositions within a given context can be implied, is called a deductive system.

Certain other systems which require known information about each and every elementary proposition, before the truth value can be assigned to all of the elementary propositions within a given context, is called an inductive System.

Misconceptions abound in number as to the relation between deductive and inductive systems. The outstanding example of one such error is the general view that deductive and inductive systems are two separate entities of study and application. Nothing could be further from the truth as the following examples will illustrate:

- (a) 1. All men have beards.
 2. John is a man.
 3. John has a beard.

- (b) 1. Ann is ill.
 2. Ann is in bed.
 3. Ann will not play with her friends today.

(a) represents a deductive system, whereas (b) represents an inductive system. The outstanding differences between (a) and (b) is that the third proposition in (a) is implied directly by the first two propositions of (a). (For the sake of clarity, I will call the first two propositions premises, and the third proposition the conclusion.)

Thus, in (a) (deductive system) the conclusion is directly implied by the premises. Whereas in (b) (inductive system)

the conclusion was not directly implied by the premises of (b). The conclusion of (b) is implied by the premises of (b), but the implication is one of degree.

Thus, the difference between a deductive system and an inductive system is one of degree. Degree of what? Degree of strength of implication between the elementary propositions in a given context.

If, as in Example (a) All men have beards.

John is a man.

John has a beard.

(Let it be assumed at this point, unless otherwise declared, that the given propositions 1 and 2 of (a) and (b) are true). the elementary propositions as so related that the implication is direct and no further information is needed in support of the implications, the system is deductive. (It must be noted that further information is needed. Such information is needed to substantiate the initial factual claims of 1 and 2. Discussion as to this point will be found further into the body of this discourse).

In Example (b) Ann is ill.

Ann is in bed.

Ann will not play with her friends today.

the elementary propositions are implied to one another but not directly. The premises substantiate the declaration of the conclusion (the third proposition) only to a limited

degree. The support provided by the premises of (a) (deductive system) is direct and complete. To increase the strength of implications between the propositions of (b), further information is needed. Such information comes in the form of an increase in number of given propositions.

The degree of strength of implication between elementary propositions may be viewed as follows:

Deductive

Increase in the strength of implication between the propositions provided by any given defined context. Inductive

Meaningless

(Thus, in addition to being a "study of all manner of order", logic deals in great depth with the strength of such an order).

The concept that deals with the strength of substantiation (support or implication) is called inductive probability. (The general term probability is used in many texts, but the term lacks clarity of use. This lack of clarity becomes apparent when the discussion regarding "information needed to substantiate the initial factual claims", mentioned previously is dealt with).

Thus, the inductive probability of the elementary propositions of a given context is:-

the degree of support

or the strength of the support

or the strength of substantiation
 or the degree of implication

that exists amongst all the elementary propositions produced from a given context.

The consideration of the truth values (i.e. whether the proposition is true or false) of premises found in examples (a) (deductive) and (b) (inductive) systems, is of the utmost importance.

Up to this point in the discourse, it has been assumed that the premises (or elementary propositions) possessed the truth values - true. Such assumptions are without merit unless they (the premises) themselves, are substantiated. A closer examination of Example (a) will illustrate the problem.

1. All men have beards.
2. John is a man.
3. John has a beard.

1 and 2 implied directly that 3 is so (true). But are 1 and 2 so (true)?

Thus, the premise 1 "All men have beards" can only be true if 1 is itself a conclusion to another set of propositions known as premises:

- i.e. premise - Statement (a).
- premise - Statement (b).
- conclusion - "All men have beards".

The same applies to the premise 2 "John is a man":

i.e. premise - Statement (a).

premise - Statement (b).

conclusion - "John is a man".

Thus:

premise - Statement (a).

premise - Statement (b).

Conclusion - All men have beards.

premise - Statement (a).

premise - Statement (b).

conclusion - John is a man.

premise - All men have beards.

premise - John is a man.

conclusion - John has a beard.

Thus, the support of premises is determined by personal knowledge or episteme of the person who happens to be perusing the initial premise. The factual personal knowledge (or episteme) in relation to the given premises:

All men have beards.

John is a man.;

immediately produces the problem of degree of substantiation.

The degree of substantiation that exists between the factual knowledge and the given premises is called the epistme probability. The degree of support or substantiation

that exists between the given premise and its conclusion is called the inductive probability. That is:

Factual proposition - premise 1. All men have beards.

Factual proposition - premise 2. John is a man.

The degree of support provided by the factual proposition or knowledge to the validity of the premise 1 and 2 is called the episteme probability.

The degree of support provided or the amount of substantiation provided by the premise to the conclusion, is called the inductive probability, i.e.

premise 1.

Inductive
probability

premise 2.

conclusion - John has a beard.

It is the probability of the truth of a statement in relation to our stock of relevant knowledge. If we have all the relevant knowledge (information) we have a DEDUCTIVE SYSTEM. That which we lack, contributes to the episteme probability. As Godel's theorem states, "that a mathematical system cannot be self descriptive, all the rules necessary for describing the system cannot be stated within the system!"* An inductive system is one which accepts improbability, but is based on probability.

This 'excursion' into logic has brought us back to the same problem, the 'no one' in the Minkowski space/time relationship. The delineation of time and space, contained and conveyed information, and deduction and induction all

* Godel in Newman (1960)

depend on a system of comprehension or interpretation and upon certain properties of that system. The main inference which can be drawn is that:- Absolute 'deduction' is impossible and that a general system can at the best approach deduction by attempting to contain all the information which relates to the system.

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